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1880.

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By John C. Peters M.D.

Of New-York Sept 25 1883

NAVY DEPARTMENT.
BUREAU OF MEDICINE AND SURGERY.

REPORT

ON

YELLOW FEVER

IN THE

U. S. S. PLYMOUTH IN 1878-'9.

OMNIBUS AB ORIS HIS MARIBUSQUE
BUREAU. MED. AND SURGERY.

PREPARED UNDER DIRECTION OF PHILIP S. WALES, SURGEON-GENERAL
U. S. NAVY.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1880.

- 3468 -

NAVY DEPARTMENT,
Washington, February 24, 1880.

SIR: Report to Chief Bureau of Medicine and Surgery immediately, for duty as president of a board, to make a sanitary inspection of the United States steamer Plymouth, at Portsmouth, N. H., and you will proceed to the navy-yard at that place, and report to Commodore Beaumont for the duty assigned.

Naval Constructor T. D. Wilson and Surgeon J. H. Kidder will be associated with you on this duty. Detailed instructions will be furnished you by the Chief of Bureau of Medicine and Surgery, to whom you will make your report.

After completing this service, return to Washington, D. C., and resume your present duties.

Very respectfully,

R. W. THOMPSON,
Secretary of the Navy.

Medical Inspector R. C. DEAN, U. S. N.,
Washington, D. C.

12659

BUREAU OF MEDICINE AND SURGERY,
NAVY DEPARTMENT,
Washington, D. C., February 25, 1880.

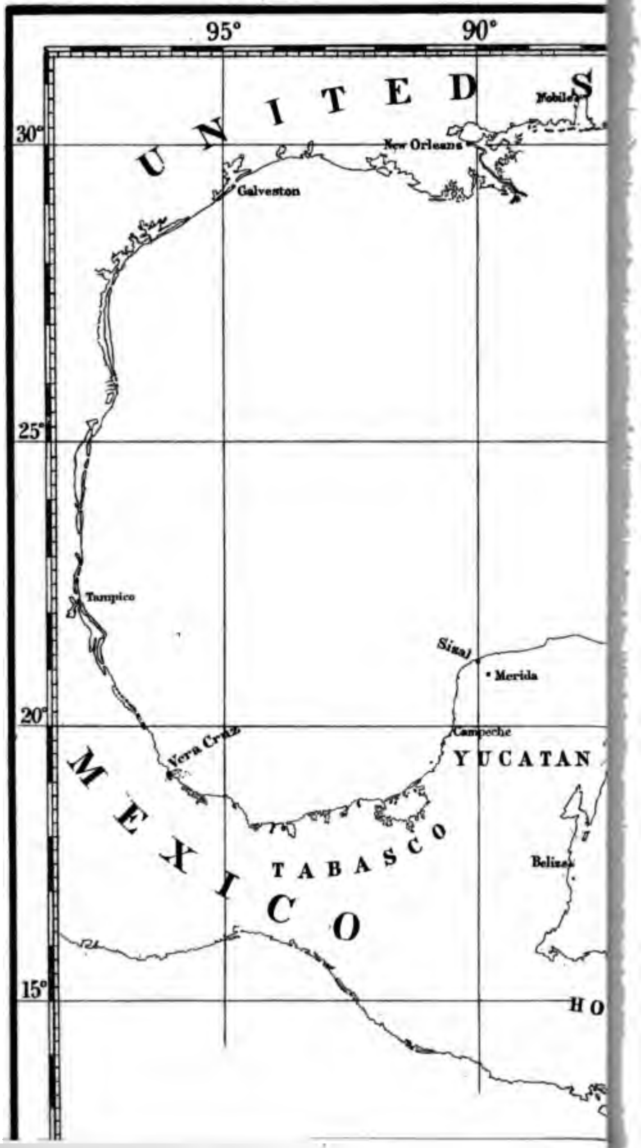
SIR: After reporting to Commodore Beaumont for the duty to which you have been assigned, you are instructed to make an examination of the Plymouth with the view of determining what sanitary measures may be necessary to place her in a condition to receive a crew on board with safety, and perform the usual service of a cruising ship at sea.

In conducting this investigation, which is expected to be exact and complete, you will endeavor to make a personal inspection of every part of the ship's interior. If, in the course of the examination, it may be necessary to raise any portion of the inner planking, or the floor of any magazine or store-room, or remove any other obstructions which may conceal accumulations of impurities or materials affording lodgment for infection, you will apply to the commandant of the navy-yard for such facilities as may be needed for the purpose.

You will report at once to this Bureau the sanitary condition in which you find the Plymouth, with your recommendation as to the best method, under the circumstances, of thoroughly disinfecting and purifying her, so as to remove all danger of future sickness from causes now within the ship, if any such exist.

In connection with this duty the Bureau desires that you will extend your investigation so as to collect all the information obtainable in regard to the recent occurrence of yellow fever on board the Plymouth, and especially to ascertain, as far as practicable, whether the second appearance of the disease in March, 1879, was due to the continued action of the original infection, supposed to have been received in November, 1878.

You will also inquire minutely into all the circumstances attending the exposure of the ship and her stores, clothing, coal, and other contents, to a freezing temperature at the navy-yard,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REPORT

ON

YELLOW FEVER IN U. S. STEAMER PLYMOUTH.

The recurrence of specific yellow fever on the Plymouth while at sea, in the month of March in a temperate latitude, the ship having just sailed from Boston after exposure to the cold of a rigorous northern winter, and not having touched at any other port or encountered any new source of infection, presents a subject well deserving of particular inquiry.

At this time when research into the nature of yellow fever has been so greatly stimulated by its recent ravages, it will doubtless be of interest to ascertain the reason for this persistence of the infection and to detect the place of concealment of the poison in the ship, as well as to investigate the circumstances which favored its resistance to agents usually relied on to destroy it, and its subsequent development into renewed activity.

But it is also believed that a careful study of the events which occurred on the Plymouth may lead to general conclusions of the highest value in naval sanitation, and may yield instruction as to the means of protecting our ships of war from similar disaster in the future, which is the true practical purpose of this report.

A review of the character of the previous diseases on the ship and of her exposure at various times in infected localities is a necessary preliminary to a thorough understanding of the matter to be considered, and the first part of our report will be devoted to this subject.

The screw corvette Kenosha, afterwards named the Plymouth (second rate, 12 guns, 1,122 tons, 2,400 tons displacement), was built at the navy-yard, New York, launched at midsummer, 1868, and reported as completed in February, 1869.

Her frames were of live oak and white oak, in the proporti of 15,079 cubic feet of the former to 18,000 of the latter, and in her whole structure 78,028 cubic feet of white oak were used.

She is what is commonly called a single-decked ship, and is described as "having always been a comfortable vessel for the crew, with more than usual berthing room, and with sweet and accessible bilges; altogether, a particularly clean ship." The total air space of her berth-deck is 34,304 cubic feet, and her average ship's company 193 men. Deducting ten cubic feet for each man and his hammock, we have an average air space per man of 187.3 cubic feet.

The Plymouth was commissioned on the 20th of January, 1869, before completion, and on the 25th of February following sailed from New York for the European station, bearing the pennant of Commodore W. H. Macomb. After a year's absence in Europe she returned to the United States, bringing the remains of Mr. George Peabody, and arrived at Portland, Me., on the 7th of February, 1870.

On the 12th of July she sailed again from New York, after undergoing extensive repairs, for Lisbon and the European station, where she continued cruising for three years. At the end of this time she returned once more to the United States, touching at the island of Fernando Po, in the Gulf of Guinea, in March, 1873; at St. Paul de Loando, on the west coast of Africa, in April, and at Barbadoes, in the West Indies. She was put out of commission in June, 1873, at Portsmouth, N. H.

During the whole of this long cruise of three years and a half there was no epidemic of disease on board the Plymouth. Remittent and intermittent fevers appear in every quarterly report of sick, but not in any great proportion.

While the ship remained at Portsmouth, N. H., she was surveyed by a board consisting of Commander C. C. Carpenter, Naval Constructor T. E. Webb, Carpenter A. O. Goodsoe, and Foreman Shipwright Wm. F. Noyes. This board reported, on the 14th of July, 1873, that a few of the frame timbers above the water-line showed signs of decay, and that decay had also appeared on the outside planking above the copper under the fore chains and between the main and mizzen chains. In the opinion of the board all the frames were at that time sufficiently good to last another cruise.

In accordance with the recommendations of the board of survey the ship was repaired between July, 1873, and October, 1874, to the extent of $77,928.37. These repairs included the replacement of the decayed outer planking, supplying new decks in part, and several new hanging knees upon the berth-deck, these parts proving to be already extensively decayed.

On the 12th of October, 1874, the Plymouth was recommissioned at Norfolk, Va., under the command of Capt. John H. Russell. Her medical officers were Surgeon Somerset Robinson and Assistant Surgeon D. O. Lewis. During this cruise the vessel was stationed almost continuously in the Gulf of Mexico and the West Indies. A summary of her changes of station and of incidents that appear to throw light on the objects of this inquiry, including a note of the cases of malarious diseases reported upon the medical returns of the vessel, is here presented.

Month.	Stations and sanitary history.	Cases of malarial diseases.	No.
1874.			
October	12th, commissioned at Norfolk, Va	One case continued fever; recovery.	1
November	Norfolk and New York		
December	do		
1875.			
January	21st, Key West	Four cases continued fever; recoveries.	4
February	do		
March	do		
April	Key West and Sand Key	4th, one case entered as "febris flavà" appears from history to have been simple continued fever; four cases continued fever; recoveries.	5
May	Key West and West India Islands		
June	do		
July August September	Key West, Gulf of Mexico, and Norfolk	Three continued fever; three intermittent fever; recoveries; one remittent transferred.	7
October November December	Norfolk, Va	Two continued fever; three intermittent; recoveries.	5
1876.			
January	Norfolk and Fortress Monroe	One continued fever; covery.	
February	do		
March	Hayti, 25th		

Month.	Stations and sanitary history.	Cases of malarial diseases.	No.
1876.			
April May June	Hayti, St. Domingo, Jamaica, and Port Royal, S. C. (June 5.)	Two continued fever; three intermittent fever; recoveries; one remittent transferred.	6
July August September.	Port Royal and northern ports	Three continued fever; one intermittent fever; recoveries.	4
October November. December.	Philadelphia, Norfolk, and Key West. (December 30.)	One intermittent fever; recovered.	1
1877.			
January February March	Pensacola, New Orleans, and neighboring ports. Assistant Surgeon Lewis relieved by Assistant Surgeon W. A. McClurg.	Two continued fever; recoveries.	2
April May June	New Orleans, Mississippi River, and Mexico. Assistant Surgeon A. C. Heffernan reported	One remittent fever; recovery.	1
July	Port Royal, S. C., Norfolk, Washington, July 23.	One intermittent	1
August	New York		
September	Surgeon Robinson relieved by Surgeon E. S. Matthews. Assistant Surgeon J. C. Byrnes reported.		
October	Norfolk	December 14, one case fever, nature unknown, sent ashore at St. Domingo; December 24, one "Chagres fever"; December 27, two "Chagres fever"; December 29, two "Chagres fever"; in all, seven "Chagres fever," recoveries, and two doubtful transferred; (two febris enterica.)	9
November	do		
December	St. Thomas, 4th; San Juan, 11th; Puerto Plata, 14th; Aspinwall, 20th; Sea, 27th.		
1878.			
January	Havana, 9th; Key West, 13th; Port Royal, 20th; Norfolk, 27th.	Five intermittent fever; one continued fever; recoveries.	6
February	Norfolk		
March	do		
April	Puerto Plata, 20th	Three continued fever; two intermittent fever; recoveries.	5
May	Samana Bay, 1st; St. Domingo, 3d; Sea, 4th; Kingston, Jamaica, 8th; Sea, 12th; Brazos, Mexico, 24th; Sea, 26th; Pensacola, 29th; Sea, 12th; New York, 22d.		
June	Surgeon Matthews detached 23d and relieved by Surgeon T. Woolverton, July 2.		
July	New York	Two continued fever; two intermittent fever; recoveries.	4
August	do		
September	Sea, 24th; Portland, Me., 29th		
October	Portland, Portsmouth, Sea, 6th; Santa Cruz, 20th; St. Thomas, 22d; Santa Cruz, 26th.	Seven yellow fever; three continued fever; one intermittent; three deaths; eight recoveries.	4
November	Santa Cruz to 7th; Norfolk, 19th to 24th; Martha's Vineyard, 26th; Provincetown, 28th to 30th. Portsmouth, Boston, December 17		

Month.	Stations and sanitary history.	Cases of malarial diseases.	No.
1879.			
January	Boston, freezing and disinfecting ship	Two yellow fever; one continued fever; one intermittent fever.	2
February	Boston		
March	Boston to 16th; Bermuda, 26th to 28th; Sea, en route to United States.		
April	Sea to Vineyard Sound and Provincetown, 6th; Portsmouth, 7th.		
May	Put out of commission, 17th.		
			*68

* Besides nine yellow fever.

A few cases of malarial disease are reported every quarter, whatever the season of the year or climate in which the Plymouth was cruising, from which it is to be inferred that during this period the ship presented within herself conditions favorable to the development of affections of this class.

On the 4th of April, 1875, the ship being then at Key West, a case is entered in the medical journal as "Febris flava." The man was captain of the fore-hold, and was required to spend much of his time below. On the morning of the above date he fell on deck and was carried below in a state of insensibility. He had cramps in his legs, nausea, and vomiting, with high fever. The malady yielded promptly, however, to quinine, the urine was at no time albuminous or suppressed, and the patient was discharged to duty in eleven days. In the absence of records of pulse and temperature, the evidence is insufficient to establish the diagnosis. At that time yellow fever had been declared epidemic in Key West, as appears by the telegrams and official reports of Capt. J. H. Russell, her commanding officer, presented herewith,* and every sharp and sudden febrile attack was justly looked upon with suspicion. Schooner loads of vegetables and fruits were almost daily arriving from Havana, and no precautions were being taken by the local authorities to prevent the constant importation of the infection.† The fleet was, however, withdrawn from the anchorage near shore, and all persons required to be on board by 10 p. m.

It is scarcely probable that the Plymouth can, at this ti have escaped exposure to the infection of yellow fever; but it failed to effect a lodgment within the ship, which remained for the most of the summer in the Gulf of Mexico, carrying stores to Brownsville, Tex., and taking in coal from the infected port of Key West.

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* See Appendix A.

See (Appendix A) Captain Russell's letter, March 23, 1875.

Having wintered at Norfolk, Va., the Plymouth returned to the West Indies in the following spring, where she continued cruising until July, 1876. In January, 1877, she was sent up the Mississippi River. In December, 1877, she made another visit to the West Indies. By this time she began to show herself to be a decidedly unhealthy ship, with a marked tendency to the development of zymotic disease.

Arriving at St. Thomas on the 4th of December, the Plymouth remained until the 11th in that port. On the 9th James F. Cleary, quartermaster, was sent on shore to the hospital with fever. Assistant Surgeon J. C. Byrnes reports that the symptoms in the case resembled those of yellow fever, and that the man was transferred at once to St. Joseph's Hospital on shore. There were no notes of pulse or temperature, but the records of the department show that the man recovered and was discharged from the service June 16, 1879.

On December 14, the ship having just arrived at Puerto Plata, St. Domingo, after touching at San Juan on the 11th, James Fodley, seaman, was taken suddenly ill and sent ashore to the hospital, the diagnosis being "*febris*, nature unknown." Assistant Surgeon J. C. Byrnes notes his temperature as 104.2° Fah.; pulse, 112; respiration, 30. "A short time before the attack the patient was in the full performance of his duty." *

On December 24, shortly after the occurrence of the above cases, while the Plymouth was at Aspinwall, there was an outbreak of Chagres fever on board, and the ship at once went to sea. The invasion in all these cases was conspicuously sudden, but their clinical history as detailed in the medical journal indicates that they were not in other respects different from the form of fever usually endemic at various places on the Isthmus of Panama. All recovered.

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* This patient ultimately recovered and was discharged from the service at New York, February 6, 1878.

By the 1st of February, 1878, the ship was again north, having touched at Havana, Key West, and Port Royal. No further cases of fever occurred. Between April and June, 1878, she made another cruise to the West Indies, not touching at St. Thomas. During this period no cases of even suspected yellow fever appeared.

On the 6th of October, 1878, she again proceeded to her station in the West Indies, sailing from Portsmouth, N. H., for Santa Cruz and St. Thomas, where she arrived on the 19th of the same month.

As it is at this time that events occurred which are most important to be considered, the following careful statement of Surgeon T. Woolverton, the medical officer of the Plymouth, is given in his own exact language:*

"The Plymouth anchored off Christianstadt on the 19th of October, and on the 21st proceeded to St. Thomas, some forty miles distant, to fill up with coal; 192 tons of good anthracite coal were put on board there by the natives. There had been at St. Thomas during the season some nine or ten deaths from yellow fever of unacclimated soldiers recently arrived from Denmark—sporadic cases—and all but one occurred in the garrison. The port was considered to be healthy, and was not quarantined against anywhere. During our stay at St. Thomas none of the men were allowed to land; officers were permitted to go ashore between 10 o'clock a. m. and 5 o'clock p. m.; the stewards did their marketing in the middle of the day, and but few stores of any kind were taken on board. On the 25th of October the ship left St. Thomas for Frederickstadt, Santa Cruz, where she remained at anchor in an open roadstead half a mile from shore until the 7th of November. The island had been free from disease during the summer; there had been but one case of yellow fever, that of a soldier from St. Thomas who had taken the disease there, and who died some three weeks before our arrival. The same precautions were taken at Santa Cruz as at St. Thomas; no liberty to the crew; no one on shore after sundown, and the men carefully sheltered from the frequent showers of rain. The weather was hot and humid; the mean of the noon and midnight temperature from October 7 to November 7 was 83.2° Fah.; the maximum 87° Fah.; the minimum 79° Fah.

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* Hygienic & Medical Reports, Navy Department, Washington, 1879, p. 659, *et seq.*

"From the time of leaving Portsmouth there had been but two or three names on the sick list, and there had been no case of fever of any kind.

"On the evening of the 4th of November Charles Bianchi, marine, berth-deck cook, reported that he had a chill and was feeling badly; on the 5th there was decided fever with headache and restlessness, fever continued high, and on the 10th the temperature rose to 105.6; pulse 95; stomach became irritable, and in the evening he had 'white vomit.' The case was reported to the commanding officer as one of yellow fever.

"On the evening of the 5th, it being pleasant, most of the ship's company were sent on shore for battalion drill. Two of the midshipmen, Mr. Rollins and Mr. Mallory, who had perspired freely during the exercise, after coming from shore stood watch; Mr. R. from six to eight o'clock, Mr. M. from eight to midnight, without having changed their clothing. They both had a rigor during the night, and in the morning were sick with fever and headache. Mr. Rollins's fever was higher and his stomach symptoms more distressing than Mr. Mallory's. On the evening of the 6th, Moore, marine, had a chill followed by fever and headache. The use of the civil hospital at Frederickstadt was kindly placed at our disposal, and Bianchi was transferred thither at 10 o'clock a. m., where black vomit set in in the afternoon. The midshipmen and Moore were transferred at 1.30 p. m. on the 7th, when the ship got under way for Norfolk.

"On the same evening Mr. Hoffman, assistant engineer; White, marine; and Winkler, marine, were sick with fever; their disease ran a mild course, and they were all convalescent within a week. The two marines were sent to duty November 22, well. Mr. Hoffman had an irregular pulse and violent palpitations during convalescence, and did not rapidly regain his strength; he returned to duty November 30. The clothing of these patients was disinfected, and their blankets thrown overboard.

"After our arrival at Norfolk we learned that Mr. Rollins had died on the 10th, Bianchi on the 11th, and Mr. Mallory on the

14th of November, at Santa Cruz. All the clothing and effects of these officers had gone ashore with them; the bedding of the four patients was sent with them to the hospital; the clothes of the nurses were thrown overboard.

"On the 8th of November the berth-deck, sick-bay, steerage, and wardroom were fumigated with sulphur, and a mixture of the sulphate of iron and chloride of lime was poured into the bilges; all bags and hammocks were aired aloft. On the 10th the fumigation was repeated.

"The ship arrived in Norfolk November 18th and was allowed pratique.

"November 23 left Hampton Roads for Portsmouth, N. H., and anchored off Quarantine Island November 30. December 1, at the request of the health officer, the berth-deck was again fumigated.

"The Plymouth remained at Portsmouth until December 16, when she proceeded to Boston for some necessary repairs, and to be broken and frozen out.

"In a report made at Hampton Roads November 17, 1878, the following opinion was expressed: 'Considering the strict sanitary rules enforced during our stay in the tropics, and the slight probability that we could have carried infection from St. Thomas, from which port we had been absent ten days before the first complaint of sickness, it is my opinion that the fever had a purely local origin inherent in the ship, and I have no doubt but that our prompt departure from Santa Cruz averted an epidemic on board. I consider that it would be unsafe to send this ship again to warm latitudes before she has been entirely broken out and thoroughly frozen out.'

"Arrived at Boston December 17; the ship was broken out at the navy-yard; nothing movable left in her in the way of stores, provisions, and clothing.

"January 8, 1879, the crew was transferred to the receiving-ship Wabash, and the vessel fully exposed to cold. Buckets of water were placed in the various store-rooms below to indicate freezing.

"January 22 the ship was hauled into dry-dock and remained there until February 4; the average temperature on deck during this time was 28° Fah., but it was colder by 10° at the bottom of the dock, which was piled up with ice.*

"January 26, fumigated by means of fifty pounds of sulphur burned below decks in eight charcoal drying stoves placed in various parts of the ship; temperature zero; water frozen in every part of the ship.

"February 2, fumigated as before; fifty pounds of sulphur; temperature 11° Fah. The fumigation extended over two days, with the ship closed; the berth-deck and sick-bay had been scraped before the process.

"The ship came out of dry-dock February 4; she was whitewashed with a mixture of lime and chloride of lime, and was believed to be thoroughly frozen out and purified. She had been overrun with ants and cockroaches; not one has been seen since the winter."

At this time repairs, to a limited extent only, were made to the Plymouth.

" The woodwork in the cabin, under the poop deck, from the top of the beams of the main deck to the under side of the poop deck beams, and two short strakes on the outside, abreast the main channel, were renewed. The gun-deck clamps abreast the foremast and about six hanging knees on each side were taken down. The wales and topsides were calked from the water-line up. Slight repairs were made to the clamps in one or two places. One place was repaired under the forecastle deck. The ship was repainted."†

After the completion of the above repairs it was reported to

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* The following is an extract from the record of temperature (Fah.) entered in the log of the navy-yard, Boston, during this period:

	Sunrise.	Meridian.	Sunset.		Sunrise.	Meridian.	Sunset.
	°	°	°		°	°	°
January 22...	21	40	36	January 31..	27	39	36
23...	34	35	36	February 1..	24	28	24
24...	24	34	34	2..	17	27	30
25...	35	44	44	3..	24	35	33
26...	10	12	14	4..	30	34	32
27...	16	25	34	5..	25	23	30
28...	40	48	45	6..	28	36	32
29...	36	34	27	7..	22	32	34
30...	15	36	31				

† Memorandum of repairs furnished by the naval constructor of Boston navy-yard, March 11, 1880.

the department that the ship was "now in good order in all departments, including engines and boilers, and we have no hesitation in saying that, with the usual conditions of cruising at sea, she may be expected to remain in a seaworthy condition for eighteen months."*

During an inquiry made subsequently at the Boston navy-yard it was ascertained that the Plymouth was known at this time to be very extensively decayed, but that, as her commanding officer was anxious to get away, and but a short cruise was intended, as little of the decayed wood as possible was disturbed.

"On March 15 the Plymouth sailed for a cruise to the Windward Islands. On the night of the 19th, during a violent gale of wind, the hatches had to be battened down, and the damp berth-deck became very warm; a tropical condition prevailed.

"On the afternoon of the 21st, Richard Saunders, machinist, reported himself sick; his face was very red and his eyes swollen and suffused; he complained of violent headache, and had considerable fever; pulse 98°, temperature 104°; fever continued high during the night; in the early morning the temperature fell to 102.5°, and it was hoped the fever would prove to be remittent; a large dose of quinine was given. The temperature soon rose again, however, to 104°; pulse 83 to 93; tongue slightly coated, broad with red edges, and showing impressions of the teeth. The fever continued until the 25th, when there was a remission, with profuse sweating; pulse 80, soft; temperature 102° throughout the day; during the night complained of nausea, and on the 26th the pulse rose to 88; temperature 104.6°, with return of headache. These symptoms subsided, and from the 27th he improved slowly but steadily. The characteristics of Saunders's fever were the sudden and violent invasion, the intense headache, with peculiar aspect of face and eyes, continued fever, remission, with sweating, urine scanty and giving a precipitate of albumen, the pulse slow relatively to the heat of the body; during convalescence skin and conjunctivæ became yellow and continued so for a week, and there was an irregular pulse. This man joined the Plymouth, in Boston, December 24, 1878.

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* Report of board ordered to report "what repairs have been ma the Plymouth, her present condition for sea-service, and the length o she will probably remain in condition for sea-service," dated Boston, 13, 1879.

"On the night of the 22d Peter Eagan, boatswain's mate, aged about 56 years, turned in feeling quite well. During the night he was taken very sick, and by the morning of the 23d he could not get about without assistance. He presented the same appearance and symptoms as Saunders, with great irritability of stomach; his case resembled remarkably one of irritant poisoning; pulse 95; temperature 103.5°; skin hot and dry.

"A diagnosis of yellow fever was made in these two cases and reported to Captain Harmony, with a recommendation not to continue the cruise; also that hot coffee should be served to the relief watch at midnight; that the men be allowed to sleep on deck under cover until we could reach cooler weather. The maximum temperature on deck had been 77° Fah.

"The ship put into Bermuda for coal, and on the night of the 25th the temperature had fallen to 63° Fah. The sick men passed through their disease pretty favorably. Saunders was convalescent about the seventh day, but Eagan, an old man, after a light remission on the fourth day, fell into a typhoid condition and died from exhaustion during a violent storm March 31; the weather had been bad and unfavorable to his recovery."*

There were no new cases of yellow fever on board after Eagan was attacked on the 22th of March. The ship was placed in quarantine at Portsmouth, N. H., on the 6th of April.

On the 9th of April a sanitary examination of the Plymouth was ordered to be made by a board of medical officers of the Navy, who reported that the infection which had caused the second outbreak of yellow fever on the Plymouth seemed to have been retained in the decayed wood of the berth-deck (an opinion likewise expressed by Surgeon Woolverton) or in the bedding or clothing of the men, and recommended that she should be disinfected by the injection of steam and by sulphurous acid gas.†

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* Hygienic and Medical Reports, Navy Department, Washington, 1879, p. 694 *et ante.*

See Appendix B.

Owing to the fact that her crew and all her stores were on board at this time, it was not considered practicable to make a thorough examination of all parts of the ship. As it appeared unadvisable to transfer her stores before the return of colder weather, further investigation was deferred until the vessel could be completely emptied of all her contents.

In the month of February, 1880, after exposure to a freezing temperature, all the stores were discharged, and a second sanitary survey ordered by the department. The present board, to which this duty was intrusted, was referred for detailed instructions to the Surgeon-General of the Navy, and was authorized to raise any portion of the inner planking or the floors of any of the magazines or store-rooms, and to remove any obstructions which might conceal impurities or materials affording lodgment for infection.*

In order to expose all parts of the ship to view, as well as to give free admission to the disinfecting agents expected to be used, the following preliminary work was performed by a gang of shipwrights, the ship still lying at anchor at the quarantine grounds in the outer harbor of Portsmouth, N. H.

Openings were made in the ceiling and knees of the state-rooms in the starboard steerage. A locker on the port side of the berth-deck, over the coal-bunker, was taken down, and openings were made in the ceiling and knees just forward of this point, portions of the planking being removed. Similar openings were made opposite the galley, on the port side (giving exit to a very offensive odor). Portions of the ceiling on the starboard side of the sick-bay were removed, and the ceiling and knees cut into and examined all along the starboard side of the berth-deck.

In that portion of the fore-hold allotted to general stores, and, abaft that, to paymaster's stores, the flooring and limber boards were entirely removed, and on the port side one of the bilge-strakes was raised. In the fore-hold proper the flooring was removed to a sufficient extent to permit examination of the bilges and the spaces beneath the water-tanks, and on the starboard side a part of the bilge-strake was cut out. Scuttles were cut in the floors of the forward shell-rooms on both sides of the keelson. In the coal-bunkers the flooring was cut through in two places. In the after-hold the flooring and a portion of the lower strake of the thick strakes were removed on both sides of the ship. Scuttles were cut to allow access beneath the floors of both magazines, and a portion of the thick strake and of the lead lining covering the ceiling was removed. Scuttles were also cut in the floors of both bread-rooms abaft the magazines, and the sheathing partly removed. The shaft-alley was examined and its after part found to be filled in solid, while in its remaining portion the bilge was accessible without the necessity for cutting.

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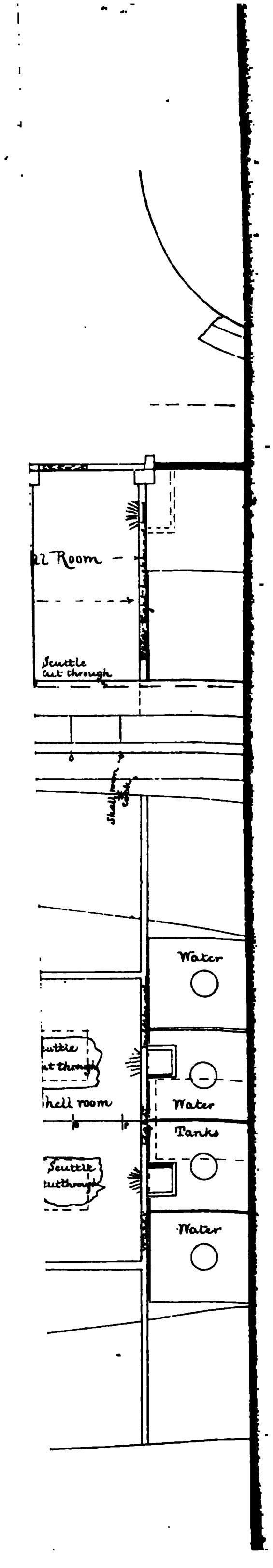
* See Appendix C.

By means of these openings we were enabled to see that the ceiling and hanging-knees, clamps, etc., were extensively decayed all along the berth-deck. This was particularly the case in the starboard steerage, opposite the galley on the port side, and in the sick-bay. The decayed wood was filled with the mycelium of fungous growths, which appeared also on the inner side of the outer planking. Behind the locker on the port side, when it was removed, was found a large quantity of partially decomposed refuse. A sink for emptying slops opened outboard from this locality and was surrounded by decayed wood. A hose-reel also hung near by. Each opening gave exit to foul air of offensive odor. This region is immediately above the port coal-bunker, and here four cases of yellow fever, all occurring during the first outbreak, were billeted. One case, occurring during the second outbreak, was billeted on the starboard side, exactly opposite, and one near the galley, localities where decayed wood was found to be particularly abundant.

In that portion of the fore hold allotted to general stores and paymaster's stores the flooring, capping to the main keelson, and the keelson itself, the frames, filling timbers, and watertight bulkhead were extensively decayed. The spaces between the frames in this locality were comparatively free from accumulations. A careful examination of all parts of the fore hold proper, of the spaces between the frames, and beneath the water-tanks disclosed nothing worthy of note. On cutting



Room
Scuttle cut through
Scuttle
hell room
Scuttle
Water
Water
Tanks
Water

through the floors of the shell-rooms a quantity of offensive air escaped. A considerable deposit of filth was here found in the bilge, next to the main keelson. On the port side a mass of nearly solid matter, consisting largely of bacteria, adhered to the inner side of the sister keelson and the angle between it and the bilge. Under the coal-bunkers nothing noteworthy besides a quantity of coal-dust which had sifted through the floor, and which appeared to have been there for a long time, was observed.

Below the plates of the fire-room there were about three inches of solid ice, and ice was standing upon the plates themselves. It was not possible to examine the parts under the boilers and engine-room. The shaft-alley and bilge in this part of the ship were free from considerable accumulations, and in good order. In the after coal-bunker on the port side a quantity of fire-wood, said to have been taken on board in the United States, was stowed; otherwise the bunkers were empty. In the after hold, on both sides, two of the filling timbers were found to have been cut off square with the molding edge (see cross-section in last figure of the accompanying plan), thus leaving a sort of dam for the retention of whatever matter might get into the spaces between the frames. On the starboard side one of these spaces was found to be completely filled with a soft mass, of intolerably offensive odor, which seemed to consist chiefly of beans in all stages of decay; the other space was equally full of sponge, clothing, chips, and other refuse, more or less decomposed. The stench from these deposits was such as to drive the workmen on deck.

Between other frames on both sides were masses of bacterial growth similar to that found in the forward shell-room; and on the port side, in the *culs de sac* corresponding to those containing the beans and refuse on the starboard side, was found a quantity of unrecognizable decomposing organic matter. It was directly above this hold that three cases of yellow fever occurred during the first outbreak. Two were midshipmen, swinging one on each side of the hatch; the other an assistant engineer, occupying the adjoining stateroom on the starboard side. Two of the three cases were fatal.

Under the flooring of the magazines was a great accumulation of decomposing chips and auger-dust, emitting a foul odor, and evidently left there when the ship was built. The spaces between the frames were free from noteworthy deposit. Under the lead lining the sheathing was entirely rotten, and blackened as if the wood had been charred, and in this rotten wood dead rats and their nests were found. The thick strakes and ceiling were badly decayed. On cutting through the bread-room floors, confined air of offensive odor escaped. A second floor had here been laid above the original floor, and between the two was a confined space about three inches deep, from which living and active flies crawled out. It is plain that, although ice had long been standing in the fire-room, this space had not been sufficiently chilled to kill the flies. The tin lining to these bread-rooms had not been carried entirely into the angle between the deck above and the ceiling, but formed with these a triangular space, within which fungous growths were found.

Owing to the fact that the lower outlets of the spaces between the frames, which were intended to open into the bilge, were in the Plymouth closed by covering boards, these spaces throughout the ship were converted into reservoirs for confined air. Other confined-air spaces existed under the limber-boards in the fore hold, under the floors of the coal-bunkers and of the forward shell-rooms, below the after magazines and bread-rooms, and behind the tin sheathing at the outer angles of the latter.

These spaces, as is shown by the presence of the living flies, are so protected from external atmospheric changes as to be practically unaffected by either heat or cold, and have probably not been reached by any of the disinfecting agents heretofore employed. The same observation applies also to the interior parts of the timbers, which are nevertheless found to be far gone in decomposition.

We are of the opinion that the various deposits of decomposing organic matter and the quantity of decayed wood above described are closely connected with the development of yellow fever on board of the Plymouth.

Numerous specimens and a plan of the ship are forwarded
ith by way of illustration. The specimens include por-
f rotten wood, showing the fungus of dry-rot in mycelium

from various parts of the ship, and the different deposits above referred to. The significance of these growths consists in the evidence which they afford that the condition of the ship was favorable to the development of low forms of organic life, which have not been destroyed by the disinfecting agents hitherto employed.

After completing the examination into the condition of the ship herself at Portsmouth, the board continued the investigation at Boston so as to determine with certainty whether all of the clothing and stores, which were suspected to have been among the fomites of the infection, had also been exposed to a freezing temperature. A careful inquiry in regard to this point showed that all the provisions, clothing, and stores had been taken out of the ship and placed in an open shed situated in an exposed part of the Boston navy-yard and had remained there for about one month, from January 8 to February 12, 1879. As shown by the record of temperature already quoted, taken from the log-book of the navy-yard, the mercury during this period was frequently below 32° Fah., the average temperature having been 28° Fah. on the dock of the Plymouth, hauled up in the dry-dock.

Subsequently the clothing, packed in bales covered with water-proof envelopes, the beef and pork in barrels, the boots and shoes in boxes, and the small stores were again returned on board. The clothing in actual use by the crew and the blankets and mattresses which had been sent with the men on board the Wabash were brought back with them on their return to the Plymouth on the 12th of February. It is not recorded that these articles were exposed to the same degree of cold as the rest of the clothing, but Surgeon Woolverton states that "the men's bedding was frequently aired during the winter, and once at least the fact is noted in the ship's log with a temperature of 24° Fah. Many of the men availed themselves of the opportunity to have them [illegible] washed in Boston."*

These stores were still in the ship on her return in March, after the recurrence of fever on board, and were not removed from her until February, 1880, when they were transferred to the paymaster's store-rooms at the navy-yard at Portsmouth.

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*"Yellow Fever on the Plymouth," Hyg. and Med. Report, 1879, p. [illegible].

N. H., for the purpose of being again exposed to the action of cold. The navigation and engineer's stores were exposed to a dry heat of 260° Fah. in an oven constructed for baking "cores." A sickening odor is said to have been exhaled from the flags and signals when heated.

It is a circumstance worthy of being particularly noted that many of these stores bore the mark "Rio Janeiro," and had been returned from the naval store-house at that place. Some among them, such as the glass jars containing pickles, etc., were packed in straw and contained in loosely covered boxes, receptacles well adapted to retaining infection.

The island of Enchados, on which the naval store-house at Rio Janeiro is situated, has long been regarded as a thoroughly infected place and has been so reported by medical officers of the Navy.*

It thus appears that all ordinary and such unusual precautions as suggested themselves were taken to prevent a recurrence of the disease; the cause of which, nevertheless, remained on board, having successfully resisted both sulphurous acid and a degree of cold below the freezing point. Whether the sulphurous acid vapor penetrated to every recess of the ship is doubtful, there being no evidence attainable bearing upon this point. The examination of the ship already described opened up many parts which must have been effectually protected against the freezing temperature recorded. So that, if it be granted that the yellow-fever poison was actually imported into the Plymouth, and that it (the poison) is endowed with the power of lying dormant under conditions unfavorable to its development without losing its potential vitality, we are of the opinion that the precautionary measures adopted in the Plymouth, energetic and well-intentioned as they were, were not sufficient to insure the destruction of the cause of the disease. Further investigation and experiments, which will be detailed in a subsequent part of this report, upon the application of dis- cting agents, have, moreover, confirmed and strengthened

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ort of Dr. Green, U. S. N., on the medical topography of Rio de o, Sanitary and Medical Reports, 1873–'74, Bureau of Medicine, Navy ment, p. 753.

the opinion expressed in our preliminary report to the Surgeon-General, that extensive decay in the wood work of a ship increases vastly both her susceptibility to infection and the difficulty of removing disease by disinfection. In the Plymouth decay began early and progressed rapidly, as has been already shown, partly because of the quantity of white oak used in her construction, and partly because of the sealing up of her frame spaces, and the numerous dark and confined boxes into which the system of flooring and bulkheading followed divided her interior, as will appear more clearly when the subject of the prevention of yellow fever comes to be considered.

The localities from which it is most probable that the disease was imported are St. Thomas and the island of Enchados. Coal was taken on board at the former place, from an open shed, and yellow fever has been so often traced to St. Thomas as a starting point, that it must always lie under particular suspicion. The island of Enchados was doubtless infected at the time that the stores above referred to were taken thence, but the time which had elapsed since their reception into the Plymouth, and before the outbreak of this disease, renders it a less probable source of infection than St. Thomas. We have found no direct evidence bearing upon this point.

The Plymouth is by no means the first ship of which it is recorded that yellow fever became epidemic on board after it had been supposed that thorough disinfection had been practiced, and before she had touched at any port within the yellow-fever zone.* Her experience occurred, however, at a time when the attention of the medical profession and of the public was directed particularly toward the natural history of yellow fever, and has furnished the text for arguments upon many of the questions which are still subjects of controversy among those especially interested in the disease.

These questions are so numerous and the shades of opinion regarding them are so various that we have found it desirable, before offering our suggestions with regard to measures of prevention and disinfection, as required by your order, to give a

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*See, for example, the histories of the United States ships General Greene (1800), Enterprise (1825), and the British ship L'Éclair (1845), reported by La Roche, vol. ii, p. 425 *et seq.*

short account of the disease itself as understood by us, and of the conclusions upon which our recommendations are based. In so doing we shall refer particularly to those aspects of yellow fever which affect the naval service afloat, and rely as much as possible upon the testimony of naval surgeons, as published in the reports of our own and foreign services, to support such opinions as we advance.

Yellow fever is an acute, specific, infectious disease, characterized by headache, nausea, suffusion of the eyes and cutaneous surface,[*] high temperature with a comparatively slow pulse, abnormal fluidity of the blood, hemorrhages from the gums, nose, and gastro-intestinal mucous membrane (black vomit), albuminous urine deficient in chlorides,[†] the secretion being often suppressed, and yellowness of the skin and conjunctivæ. Rachialgia, delirium, petechiæ, and sudamina are frequent but not characteristic accompaniments. The period of incubation rarely exceeds five days; the onset is sudden, the patient being at once prostrated, and the most important lesion is of the blood, which becomes abnormally fluid and so altered in its composition as to be, in fatal cases, incapable of maintaining the nutrition of the body. There is probably a fatty degeneration of the white corpuscles.[‡] The liver is found *post mortem* to be fawn-yellow or "nutmeggy"[§] in color and to have under-gone more or less fatty degeneration. This lesion, which was noticed by Louis in 1828, appears to be always present and is one of the distinctive marks of the disease. The bladder is often contracted upon itself, its walls thickened, and its mucous lining congested; the kidneys and spleen are also often congested and contain extravasations of blood; but besides the changes in the blood and liver above noted there are no anatomical characteristics which are known to be constant.*

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[*] Dr. S. M. Bemiss, of New Orleans, is of the opinion that one of the early lesions is a paralysis of the vaso-motor nerves, producing blood stasis, which is directly connected with the yellowness of the skin and the appearance of albumen in the urine. Am. Jour. Med. Sc., April, 1880. p. 450.

[†] "The remark of Heller (Br. & For. Medico-Chirurgical Review, July, 1853) that he had found the albumen in the urine in something of an inverse ratio to the chlorides, has been verified in the examination of the urine of these patients; for when albumen was found to be abundant then the chlorides were absent, and with the disappearance of albumen chlorides again made their appearance." Deputy Inspector-General Donnet's report upon the yellow fever epidemic of 1866 at Port Royal, Jamaica.—Stat. Rep. on the Health of the (British) Navy, 1867, p. 109.

[‡] See Surgeon G. M. Sternberg, U. S. A., in Preliminary Report of the Havana Yellow Fever Commission, Washington, November 18, 1879, p. 16; also Joseph Jones, Yellow Fever Epidemic of 1878, New Orleans Med. & Surg. Journal, vol. vi, p. 599.

[§] Donnet, *op. cit.*, p. 112. Proceedings N. Y. Path. Soc., Med. Record, September 24 and October 22, 1879.

The clinical history is short in fatal cases, which often terminate upon the fourth day. The period of accession usually embraces from twenty-four to forty-eight hours, and may be considered to represent the actual duration of the disease. This stage is followed by a so-called "stage of calm," marked by a more or less decided remission of all symptoms, during which the tendency is toward recovery if the disorganization of the blood be not too great to permit of the continuance of its functions. It is during this stage that the damage done during the paroxysm shows itself, and death occurs either at once, from total destruction of the blood as a nutritive fluid, or later, from intercurrent lesions consequent upon its impairment. Convalescence is slow, and likely to be interrupted by exposure to sudden changes in the weather. "The danger line of body temperature descends progressively from the onset."† Yellow fever is, therefore, a fever of a single paroxysm.

It is limited in origin locally by the parallel of 48° north latitude, and a corresponding but undetermined parallel of south latitude. It has occurred at so high an elevation as 4,000 feet above the sea level (Newcastle in Jamaica). But, as a rule, it is epidemic in low districts on the sea-coast, and rarely occurs beyond an elevation of 2,500 feet above the level of the sea.* The specific poison is not active at a temperature below 72° Fah. Yellow fever is also limited locally, as to its origin, to the western hemisphere, arising in the great Atlantic intercontinental gulf, as does cholera in the similar Indo-Chinese gulf of the eastern hemisphere.† Although the disease has frequently become epidemic in Europe and has been reported from so far east as Cairo, it has never retained its foothold in the eastern hemisphere longer than a single season.

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*For a careful review of the histological characters of yellow fever so far as they have been studied, with a recent bibliography of the subject, see Pathological Histology of Yellow Fever, by J. J. Woodward, surgeon, U. S. Army, Supplement No. 4, National Board of Health Bulletin, April 6, 1880. Dr. Woodward does not find that the changes in the blood, exclusive of the appearance of fat granules in the white corpuscles above referred to, are of such a character as to be apparent on microscopic examination. See also Dr. Stillé's lecture on yellow fever, Med. Record, March, 1879, pp. 193–217.

†Dr. S. M. Bemiss, *loc. cit.*

Second attacks are scarcely more common in yellow fever than in small-pox or measles.‡ Persons born or long resident in districts subject to the disease, who are then said to be "acclimated," are also protected to a less extent, but the immunity thus acquired may be lost by long residence in regions beyond the "yellow-fever zone."§ In what way such an immunity can originate it is difficult to imagine. The fact appears to be well-established, however, and suggests an analogy with the so-called Colles' law in hereditary syphilis, whereby the mother of an infected child, although presenting no evidence of having contracted the disease herself during the period of pregnancy, is found to be protected against infection from the child after its birth.[*] The fact that a single attack protects its subject from infection thereafter, considered in connection with the decided specificity of the disease, affords some hope that if the *materies morbi* should ever be discovered, the terrors of yellow fever may be abated by the practice of inoculation, under circumstances favorable to a harmless result.

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*Aitken, Practice of Medicine, ii, p. 481.

"The facts of 1869 show that this immunity is but relative, and that, when unacclimated Europeans are crowded together on high levels, the disease may rage as it does on the shore." La Fièvre Jaune à la Martinique, par L. B. Berenger-Féraud, Paris, 1878, p. 64.

†"It is along the coast of South America, in the Gulfs of Darien, of Honduras, of Mexico, and along the shores of the island of Cuba that the generative atmospheric condition (*la disposition atmosphérique génératrice*), the 'medical constitution,' of yellow fever shows itself first, and it is for this reason that yellow-fever epidemics have always started from these localities." Féraud, *op. cit.*, p. 100. See also Lecture on Yellow Fever, by Dr. Alfred Stillé, reported in Medical Record, March, 1879, pp. 193 and 217.

‡"We have never attended the same person in two attacks of the disease, and know of but one altogether reliable observer who has treated the same individual through two attacks." Bemiss, *loc. cit.*, p. 452.

§See Surgeon J. R. Tryon's report upon the epidemic of 1874 at Pensacola, Sanitary and Medical Reports, United States Navy, Washington, 1875, pp. 459–462. (The unprotected, exposed, and not attacked were only 3.29 per cent. of all cases). Med. Insp. John Y. Taylor on the epidemic of 1878 at the New York Navy Yard, Hygienic and Medical Reports, 1879, p. 478. Preliminary Report Havana Commission, 1879, p. 5. Dr. Donnet, *op. cit.*, p. 120. Report of Sanitary Commission of New Orleans upon Epidemic of 1853, New Orleans, 1854, pp. 4, 9, 262 *et passim*. (The number of deaths in this epidemic was 8,101, or 13.49 per cent. of the unacclimated population.)

Whether a partial immunity is enjoyed by the dark-skinned races or not is still an open question. During the epidemics of 1878 and 1879 in the Southern United States the mortality among the negroes was very severe, although less in proportion than among the whites. Féraud asserts positively[†] that in Martinique neither negroes nor Chinamen were any better off than other races, and it should be remembered, in discussing the supposed less liability of negroes to yellow fever in the Southern States, that they enjoy, almost without exception, whatever degree of protection is afforded by acclimation. In mild epidemics it is to be expected that acclimated persons will suffer less than strangers.[‡]

The disease is doubtless *infectious*, but the evidence in favor of *contagion* is not conclusive. Many instances are recorded of the occurrence of yellow fever on shipboard wherein those persons most exposed by personal service upon the sick escaped.[§]

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[*] For cases to show that yellow fever is not communicable to the fœtus *in utero*, see Med. Rec. N. Y., Nov. 29, 1879; Rep. of Obstet. Sect. N. Y. Acad. Med.

[†] *Op. cit.*, p. 65.

[‡] See also Stillé, Lecture on Yellow Fever, *loc. cit.*

[§] Thus, Passed Assistant Surgeon Lewis S. Pilcher (Naval Medical Essays, Washington, 1873, pp. 216, 217), reporting upon the epidemic in the Saratoga in 1869, observes: "In the circumstances attending the cases of yellow fever on this vessel, there were none which indicated that the disease was in any way propagated by contact with the sick or by exposure to the emanations or secretions from their bodies. On the contrary, those who were most about the persons of the sick escaped entirely. The apothecary and four nurses, all unacclimated and unprotected by a previous attack of the disease, who were with the sick continually, night and day, and, in some cases, unavoidably received upon their persons matters vomited by the dying, were none of them attacked. Commander Whiting, who constantly visited the sick, was one of the only two commissioned officers who escaped. * * *

When the crew of an infected ship has been transferred to a hospital on shore, or to another ship, without clothing or effects, the development of new cases has often ceased, to begin again upon the return of the men to their own vessel.* A hospital on shore may receive cases of yellow fever for months, during which the attendants and other patients are exposed to contagion, without the occurrence of any case in the hospital. When once the hospital has become *infected*, however, as shown by the occurrence of yellow fever among its *personnel*, the disease spreads with a rapidity which is in marked contrast with this previous immunity. A striking example is furnished by Dr. Donnet,† reporting upon the epidemic at Port Royal, Jamaica, in 1866–'67, of this feature in the natural history of yellow fever. Port Royal is on the end of a narrow sandspit, across the bay from Kingston, and southwest of that town. The settlement at Port Royal had been absolutely free from yellow fever for four years previous to November 27, 1866. The town of Kingston had enjoyed a similar immunity until October 14, 1866, when the first case occurred in the person of a seaman landed from the ship Jamaica, lately arrived from St. Thomas, where yellow fever was prevalent. The first case admitted to the hospital was the commanding officer of the gunboat Nettle, on the 27th November. Cases followed from the Cadmus, Steady, Doris, Constance, Jason,

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Further, not one of the quarantine officials or attendants was attacked by the disease. In the transfer of the sick (at New York in hot weather), especial care was taken to prevent as much as possible any articles from accompanying them which might act as fomites." See also Rep. N. O. San. Com. "Hirth, more than half a century ago, introduced the excrements and blood of the sick into his system in every possible way without results." p. 97.

* "The large number of cases occurring on that day (of transfer of crew to hospital ship at New York quarantine station), and their almost complete cessation from that time, is somewhat remarkable, and seems to indicate the utility of the measures for disinfection which were adopted, and especially to be due to the speedy removal of the men from the infected ship to one free from such taint." Dr. Pilcher, *loc. cit.*, p. 216. See also the record of the epidemics on the U. S. S. Enterprise, La Roche ii, p. 432, and the British ships, Hibbert p. 433, and L'Éclair, p. 443; in all of which the disease broke out again with increased violence after the return of the men to their ships.

† Statistical report of the health of the (British) navy 1867, p. 118. See also Dr. Stillé, *loc. cit.*

Aboukir, and others. Until February 16, 1867, the disease was confined to the infected persons sent from the ships, many of whom died. At this date the assistant surgeon fell ill and died, "and in May, from the circumstance of the hospital having had yellow fever cases constantly under treatment, it would seem to have acquired the conditions necessary for the spread of the contagion; for at this time the deputy inspector-general (Dr. Donnet himself), an officer, and several men under treatment for other complaints were seized with fever." It was remarked also, in the past history of the same hospital, that in several previous outbreaks the disease had been limited to the crews of the ships infected, and "that no person belonging to the hospital in attendance upon the infected cases contracted the disease; on the contrary, Dr. Blair, in his history of the epidemic of yellow fever in 1837–1840, mentions the circumstance 'that almost every case admitted into the military hospital at Georgetown (Demerara) during the epidemic, became yellow fever, no matter what the ailment on admission.'"* Féraud states that during the period from 1858 to 1869, when no yellow fever existed at Martinique, the disease was four times introduced into the military hospital, no epidemic or contagion following.†

In the case of H. M. S. Bristol,‡ at Sierra Leone, in 1865, many cases of yellow fever occurred on board of that ship among the persons who had visited the infected ship Isis as a working party to change her anchorage. No person who had not visited the Isis was attacked, although the ship's company of the Bristol was necessarily exposed to whatever contagious influence there was.

These facts suggest the conclusion that yellow fever is due to a poison which is not developed by the processes of the disease within the human body, but reaches its period of activity outside of the body. As was epigrammatically said by Admiral Dubourdieu, "*C'est le navire qui est malade.*"§

It is quite generally held by naval surgeons who have observed yellow fever that the *materies morbi* resides in the ship, and is not dependent for the continuance of its activity upon propagation from individual to individual. Thus Surgeon (now Medical Inspector) Delavan Bloodgood writes of the epidemic in the Jamestown, at Panama, in 1866,[*] that, having at length sailed northward, on the 2d day of April, the ship's company had flattered themselves that the disease would cease, "inconsiderate of the 'ferment' with which we were freighted." And again,[†] "the belief is well grounded that yellow fever never leaves certain localities which it has once invaded, and where the conditions for its existence are constantly maintained. It may seem dormant for a time, or only sporadically evincing its vitality before it arouses itself and appears epidemically." Surgeon J. R. Tryon speaks of "infected hospital buildings" and "infected marine barracks, where the disease existed to an alarming extent" during the epidemics of 1863 and 1867.[‡] Acting Passed Assistant Surgeon F. V. Greene says: "Of the fact that the germs retain their vitality for long periods of time in this section (Brazil) there can be very little doubt, as it is only on this hypothesis that the yearly outbreaks of disease can be explained."[§] Surgeon Thomas N. Penrose states of the epidemic on the Ticonderoga (1874), "That the germs of the disease reside within the ship I have no doubt."[||] Surgeon N. L. Bates, on the Brooklyn, in 1875, found that "nearly all the conditions required to develop yellow fever are constant at Rio de Janeiro."[¶] Medical Inspector Jno. Y. Taylor, writing of the Vermont at New York, in 1878, observes, "It has long been known that the so-called germs of yellow fever, while they are destroyed or rendered inert by a very high or very low temperature, under certain conditions, may remain quiescent for an indefinite time and afterwards resume their activity and powers of multiplication."* Surgeon T. N. Woolverton, on the Plymouth, during the same epidemic which led to this investigation, states his conviction "that the yellow-fever infection is confined to the hull of the ship, and especially to the rotten wood about the berth-deck."†

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* *Loc. cit.*, p. 125.

† *Op. cit.*, pp. 41, 42.

‡ Quoted from a letter by Dr. George M. Sternburg to the Medical Record, January 11, 1879, p. 46.

§ John Gamgee, Yellow Fever a Nautical Disease, N. Y., 1879, p. 136.

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[*] Medical Essays, Bureau of Medicine and Surgery, Navy Department, Washington, 1873, p. 186.

[†] *Op. cit.*, p. 200.

[‡] Yellow fever at Pensacola in 1874. Sanitary and Med. Reps. U. S. Navy, Washington, 1875, p. 452.

[§] Sanitary and Med. Reps., 1875, p. 765.

[||] Sanitary and Med. Reps., 1875, p. 477.

[¶] Hygienic and Med. Reps., 1879, p. 26.

The medical board ordered to investigate the epidemic at Pensacola, in 1874, reported their opinion that "the germs of the disease certainly exist, dormant for the winter, to revive next summer."‡ Many of the phenomena "can at present only be explained on the assumption that this cause (of yellow fever) is either itself capable of growth and reproduction outside the bodies of the sick, or that it is the product of something which has these qualities,"§ as an alcohol, for example, is the product of the growth of a *saccharomycetes.* Dr. Alfred Stillé, in a recent lecture delivered at Philadelphia,"‖ quotes the late Dr. Nott, of Mobile, as having said: "Yellow fever is not generated in the human system, nor transmitted from one person to another in any way; its poison or germ is generated outside of the human system, and is taken into the system after the manner of the marsh malaria. But, unlike the latter, its germ is portable, and may be carried from one point to another and thus propagated." Dr. Warren Stone, of New Orleans, is also quoted by Dr. Stillé to much the same effect.

This very general belief that the essential poison of yellow fever is not a product of disease in the human subject, like the poison of small-pox, for example, but is produced and developed outside of the body, is quite independent of any particular theory as to the nature of the poison, or its proper place in classification. It appears to be based upon observation of the facts already adverted to in the natural history of the disease, and to have grown up independently in the minds of several

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[*] Hygienic and Med. Reps., 1879, p. 479.

[†] Hygienic and Med. Reps., 1879, p. 691.

[‡] Hygienic and Med. Reps., 1879, p. 707.

[§] International Review, January, 1880, p. 30.

[‖] Med. Record, New York, March, 1879, pp. 193–217.

different observers as a logical explanation of the phenomena.[*] Such being the history of this opinion, it becomes the basis for practical deductions of great importance, turning the attention of those whose duty it is to guard against the loss of life on shipboard by this disease to the external and physical conditions which present themselves rather than to its clinical history.

The phenomena which characterize the inception and progress of an epidemic of yellow fever are as well established as those which mark any process in nature. If its cause has not yet been absolutely and visually demonstrated, the effects which it produces, and the laws under which it operates, have been determined by observations as often repeated, by methods as rigidly scientific, and by observers as truthful and unprejudiced as those that have established the theory of the correlation of forces or of chemical quantivalence, reasoning from phenomena the causes of which are even more hopelessly unrecognizable by the senses. It is not surprising that, notwithstanding the mass of facts which have been collected, there should not be perfect unanimity in the support of a theory that shall account for all of them, since the complexity of the problem is enormously increased by the presence of that unknown factor which disturbs all inferences drawn from the processes of disease, the force which controls life; and since the disease itself is the only absolute test as yet discovered for the presence of its cause.

We do not consider that it would fall within the limits of our instructions to discuss the various theories which have been advanced and supported with greater or less ingenuity in explanation of the phenomena of yellow fever. Whether the poison is, according to the "germ theory," a cryptogamous plant of extreme minuteness, or a particle of diseased bioplasm endowed with a primitive amœboid power of motion and multiplication,[†] or a "something in the air," a gaseous emanation, an immaterial influence similar to heat and electricity, or a wingless insect which crawls along surfaces, or whether, in fine, the disease is nothing but a malignant form of malarial fever,* are opinions which it would be unprofitable to discuss in this place, since there is not, as yet, a particle of direct evidence bearing upon the physical characteristics of the poison of yellow fever.† Nothing has been found in the bodies of those affected, in the air of the localities wherein the disease prevailed, or in the solid materials by which they were surrounded which has yet been proved to be peculiar to the disease, although the highest microscopic amplifications in skilled hands have been again and again used in their examination.‡

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[*] Dr. Bemiss is one of the few observers of great experience and high authority who hold a contrary opinion. "It [the poison] is reproduced chiefly, if not wholly, within the body, but," as he goes on to say, "undergoes some change after its escape from the body, which increases its toxic qualities." (*Loc. cit.*, p. 457.)

[†] Disease Germs: their real nature. Lionel S. Beale, M. D., Philadelphia, Lindsay & Blakiston, 1870, pp. 11, 16, *et passim*.

Whatever may prove to be the real nature of the unknown cause of yellow fever, there are certain peculiarities in its behavior which appear to define the limits within which it is to be sought. In the first place, it is portable; it clings to solid surfaces, and especially to such as, by their looseness of texture, favor the retention of minute material particles. Such articles as clothing, rags, skins, feathers, linen, and silk, are classed as most dangerous by quarantine regulations—empirical rules based upon experience only. The poison is therefore probably a solid body, and there is good reason to hope that it will eventually be demonstrated by the microscope.§

Secondly, it is *specific;* that is, it reproduces yellow fever, and no other disease. Yellow fever is as sharply defined as to its characteristics as small-pox, or typhoid fever, or cholera. The necessary inference from this fact is that the cause is always the same, and that it reproduces its like when propagated—a peculiarity of living organisms.

Thirdly. Although the poison manifests itself under certain conditions, such as are favorable to the growth of organic life, namely, a temperature above 72° Fah., moisture, ‖ and the presence of decomposing organic matter, these conditions alone are not sufficient for the production of the disease. A filthy ship, in the hot and moist climate of the Woosung River, for example, although certain to be an unhealthy ship, will never develop yellow fever on board. The disease originates only within certain geographical limits, and even when exported thence in a state of activity it runs its course only for a single season. Although capable of becoming exotically epidemic it has never yet become endemic outside of its geographical habitat. It is clear that there is a something necessary to the production of yellow fever which plays the part of a *seed*, besides the conditions favorable to the appearance of zymotic diseases in general. But, and in this regard it presents a marked peculiarity, it is not always active even within its own geographical limits and under the favoring circumstances of heat, moisture, and a nidus found to be suitable in epidemic seasons. There have been long periods of intermissions alternating with epidemics even in those localities most subject to the disease. The following table, from Féraud, who has examined the evidence relating to each epidemic occurring at Martinique since 1802, affords a striking example of this fact:*

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* The "Bancroft" doctrine. See Watson's Practice, art. Yellow Fever.

† See Preliminary Report of Havana Commission, p. 6.

‡ Certain unfinished researches upon bodies of suspicious appearance observed by the Havana Commission will be considered later.

§ Dr. Sternberg, in Rep. of Havana Commission, p. 17; Rep. Yellow Fever Commission to Public Health Association, 1878; Med. Record, November 30, 1878.

‖ Dr. E. H. Barton (report Sanitary Commission on yellow fever at New

1802 to 1808	Epidemic.
1808 to 1816	Intermission.
1816 to 1823	Epidemic.

Orleans in 1853, p. 295), after a lengthy discussion of the importance of humidity as a factor in producing disease, asserts that "*we have never had an epidemic of yellow fever in this country without this combination*" of a "nearly (and indeed often) saturated atmosphere with high temperature." (The italics are Dr. Barton's.) In a table to be found at page xiii of the introduction to the same report the meteorological averages of fifteen epidemics are given, as follows: The average duration of the epidemics was 58.33 days; the average mortality per 1,000 was 18.3.

Average temperature in shade at beginning of epidemic	80.14
Average temperature in shade at maximum of epidemic	79.60
Average temperature in shade at declination of epidemic	65.72
Average humidity at beginning of epidemic	888
Average humidity at maximum of epidemic	865
Average humidity at declination of epidemic	755

Saturation being 1,000.

See also Féraud, p. 79. Report of weather at St. Thomas and Santa Cruz, *ante*, p. 14. The average humidity on the berth-deck of the Plymouth in month of November, 1878, during first outbreak, was 790. (See diagram, 47.)

Op. cit., p. 57.

1823 to 1825	Intermission.
1825 to 1828	Epidemic.
1828 to 1838	Intermission.
1838 to 1844	Epidemic.
1844 to 1850	Intermission.
1850 to 1858	Epidemic.
1858 to 1869	Intermission.

The mean period of intermission was found to be 9 years and 1 month; of epidemic continuance 13 years and 5 months; and of 198 years concerning which there were records at Martinique, there were 107 of epidemic and 91 of immunity.[*]

Some curious facts have been recorded by this excellent observer as to several of the epidemic periods at Martinique. "All things being otherwise equal, yellow fever has not the same epidemic intensity at all times—and it is thus, for example, that it continues without interruption from September, 1802, to April, 1804, twice passing over the cool season without relaxing its violence; then from 1804 to 1805 it rages during the heat and sleeps during the relatively cool season. In 1806 its benignity is much greater than in previous years; in 1807 and and 1808 it seems to have no longer the power to reach any but new arrivals, sparing at this epoch those who already passed some time in the colony."[†] During the period of intermission from 1858 to 1869, on the other hand, yellow fever was four times imported into the military hospital without producing any epidemic or infecting any other person. And this notwithstanding the frequent presence of unacclimated French troops, on their way to and from Mexico, in the ports of Martinique.[‡] At one time the activity of the poison is so great that it passes over the cool and dry seasons with undiminished intensity, continuing with progressively diminishing activity, until, just before its final disappearance, only the most susceptible subjects are attacked. At another time even the repeated importation of the disease and the abundant presence of unprotected individuals are insufficient to excite the activity of the poison.

La Roche[§] has collected a mass of evidence which tends to show that neither excessive humidity nor excessively high temperature are sufficient to determine the "epidemic constitution," nor have the vague descriptions of "yellow-fever weather," nor the equally vague reports of blights, molds, early putrefaction, and epidemics among the lower animals been found to be sufficiently precise to bear scientific examination. Yet there is little room for doubt that a fifth condition, in addition to high temperature, humidity, a suitable nidus, and the presence of the poison itself, is necessary to the prevalence of an epidemic of yellow fever. Those authorities upon whose trustworthiness we place most reliance are of the opinion that this fifth condition is meteorological, and, indeed, it is difficult to suggest any other plausible explanation of the apparently capricious behavior of the disease. Féraud, after a full discussion of the evidence, concludes that "*sometimes importation, sometimes spontaneous origin, have been the cause of an epidemic of yellow fever at Martinique; but this importation and this spontaneous generation have not been fecund excepting under the condition that they occurred at a propitious moment, not only of the season, but moreover of a period of several years.* * * * †The best conclusion is to admit that, 1st, there must be a special atmospheric condition; 2d, under this condition importation has sometimes been the cause of an epidemic, and it is possible that spontaneous generation has also produced it."

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[*] P. 70.

[†] P. 12.

[‡] P. 41-42.

[§] Vol. II, p. 90 *et seq.*

In another place Féraud compares the progress of the disease from island to island to a "slow hurricane," increasing or diminishing in its area according to circumstances, and requiring six, twelve, or even fifteen years to bring about the necessary atmospheric conditions.‡

The sanitary commission at New Orleans refers to the "very peculiar meteorological conditions" attending the epidemic in that city in 1853,§ and Dr. Barlow, a member of the commission, lays especial stress upon the solar radiation observed during "yellow fever weather," whereby an extreme difference of temperature is observed between the sunshine and the shade.||

The first successful attempt to accurately define any of the eteorological conditions present during yellow fever (other those pertaining to heat and moisture) known to us is ex- in a very interesting letter from Dr. Charles Finlay to the Havana commission of the National Board of Health. Dr. Finlay finds that—

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† P. 104. ‡ P. 100. § Report, p. 503.

rcumstance has, however, been frequently noticed in climates not yellow fever, such as those of Syria and the East Indies.

1st. The Havana atmosphere is constantly and strongly alkaline.

2d. Its alkalinity increases from May to August, decreases from September to December, and remains low from January to April or March.

3d. In all parts of the island where the alkalinity of the air has been tested it has been found to exist, but to a less degree than in the city of Havana.

4th. The volatile alkali of the Havana atmosphere shows a tendency to form acid salts whenever the acidulated litmus contains an excess of sulphuric acid, thereby indicating a weaker base than ammonia and suggesting some volatile alkali of the "compound ammonia" (amide?) type.*

The considerations thus far presented tend, in our apprehension, to the conclusion that the poison of yellow fever is not only a material substance, but a definite organism, capable of reproduction and self-multiplication under the circumstances favorable to the growth of other organisms, whenever to these circumstances is added an undetermined factor, presumed to be meteorological. Even should the *disease* prove to be due, as suggested indirectly by Dr. Finlay, to an unorganized product of the growth of such an organism, the necessity for the assumption of an organism as the elaborator of such a product remains as urgent as if the prime cause be supposed to produce disease by its multiplication within the body. Further considerations which tend to the same conclusion are—

First. The fact that a period longer than the actual incubation of the disease is found to elapse between exposure to the original infection and the occurrence of the first case. In the Port Royal Hospital, as recorded by Inspector Donnet (see p. 30), this period of germ incubation, so to speak, is to be found within the limits of the eighty-one days which elapsed between November 29 and February 16; or, since it was not until May that the hospital was reported as fully infected, one hundred and fifty days. The Plymouth had been absent from an infected port (St. Thomas) ten days when the first case appeared,* a circumstance which led Dr. Woolverton to infer that the disease resided within the ship. The Saratoga had been in the harbor of Havana twenty-eight days when the first case appeared.† "The first case of yellow fever occurred in the city of Pensacola in the beginning of August, 1874, and about thirty days after the arrival of the infected vessels in quarantine."‡ At the navy-yard, Pensacola, in the same epidemic, the disease spread rapidly after sixteen days, two light cases, not at once diagnosed as yellow fever, having occurred at the intervals of seven and nine days respectively. These two men had been in attendance on the first case, which was fatal.

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* Preliminary Report, pp. 18, 19. Dr. Finlay also calls attention to the fact that some of the remarkable phenomena of yellow fever—*e. g.*, hemorrhagic tendency, softened and spongy gums, albuminous urine, and gastric irritability—resemble the effects of intoxication by a volatile alkali such as ammonia.

The Brooklyn arrived at Rio de Janeiro on the 19th of March, 1875, and took in coal and stores. No fever occurred until April 3, when the ship was at Cabo Frio, which is considered a healthy port.§ "Vessels which become infected are usually here (at Pernambuco) from five to ten days before the disease appears on board."‖ The Jamestown lay at Panama from the middle of November until the 30th December before the appearance of yellow fever.¶

It would be easy to multiply recorded instances which tend to show that a considerable time elapses between exposure in an infected port and the appearance of an epidemic on board of a ship, although it is impossible to define the exact time of the importation of the poison on board.

Furthermore, in most of the instances above noted, after the departure of the ships from infected ports, cases continued to occur with increased frequency at sea, so that, as has been already stated (p. 32), the medical officers became convinced that the disease resided in the ship, and was not propagated by contagion wholly, if at all.

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* Dr. Woolverton, Hyg. and Med. Reports, 1879, p. 691.

Dr. Pilcher's Report, *loc. cit.* ‡ Dr. Tryon, *loc. cit.*

Dr. Bates, *loc. cit.* ‖ Dr. Hoehling, *loc. cit.* ¶ Dr. Bloodgood, *loc. cit.*

Second. Minute algoid growths, popularly classed as "bacterial,"[*] have been observed in the blood of persons and animals suffering from several different diseases, and have been found capable of exciting similar diseases when injected into the blood of healthy subjects, even after having been dried and kept for a long period.[†]

So widely is the connection between these microscopic organisms and various diseases accepted, that the prevailing specific nomenclature of the order is based upon it.[‡] In the current number of the London Lancet (May, 1880) there are no less than three different articles, setting forth the close connection and specific relation between these organisms and various diseases. Besides the lecture of Dr. Greenfield already cited,[§] it is recorded that at the meeting of the Royal Medical and Chirurgical Society on February 24, Dr. H. Vandyke Carter presented a paper detailing the results of forty-four inoculations of the blood of the "famine fever" of Bengal upon monkeys. Dr. Carter showed the identity of this disease with the "relapsing fever" of Europe some two years ago, as well as that *spirillum* is present in the blood during the febrile paroxysms. Of 31 inoculations with spirillar blood 22 were successful, and 9 failed. Nine inoculations with non-spirillar blood, and 7 with desiccated blood, gave negative results.[||] M. Pasteur announces to the *Acad. des Sciences* the discovery that the very fatal disease called "chicken cholera" is due to the presence of a microbion, which is capable of producing the disease by inoculation. (P. 459).

Now, while none of these facts afford any evidence that the poison of yellow fever is a *micrococcus* or a *bacillus*, and there is even the strong negative evidence afforded by the microscopic

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[*] *Micrococcus, Bacterium, Vibrio, Bacillus,* and *Spirillum,* constituting Cohn's natural order *Schizomycetes,* and multiplying by transverse fission. See Dr. Ant. Magnin, Les Bactéries, Paris, 1878, pp. 50-51, and W. S. Greenfield in Lancet for May, 1880, p. 397.

[†] Koch's experiments on charbon; Rev. Scientifique, Fevrier, 1877, p. 794.

[‡] Thus we have *Bacillus anthracis* Cohn (Davaine), *Micrococcus vacciniæ* Cohn, *M. diphtheriticus* Cohn (Hallier), *M. Septicus* Cohn, *M. de la variole des animaux* Hallier,* *M. de la scarlatine* Hallier, *M. de la syphilis* Hallier, etc.

[§] On the Pathology of Infectious and Contagious Diseases. Lancet, May, 1880.

[||] Pp. 437, 438.

FIG. 1.–

FIG. 2.-

FIG. 3.

FIG. 4.

FIG. 5.

FIG. 6.

FIG. 7

FIG. 8

EXPLANATION OF PLATES.

FIG. 1.—Copy of photomicrograph taken by Havana Commission, 1879, at military hospital, Havana, showing rod-like forms deposited from the air, × 400.

FIG. 2.—Copy of photomicrograph taken by Havana Commission, 1879, at Morgan City, La., showing radiating acicular forms deposited from the air, × 200.

FIG. 3.—Rods and radiating acicular crystals formed upon glass slip exposed to the air of microscope-room, Washington, D. C., June 19, 1880, × 240.

FIG. 4.—Radiating acicular crystal formed upon watch-glass exposed to the air of a bedroom, Washington D. C., July 29, 1880, × 312.

FIG. 5.—Crystals of potassium sulphate, artificially formed from a very dilute solution, × 312.

FIG. 6.—Crystals of sodium butyrate, artificially formed from a very dilute solution, × 240.

FIG. 7.—Acicular crystals artificially formed from a solution of sodium carbonate, × 240.

FIG. 8.—Crystals formed from a very dilute solution of sodium carbonate, × 240.

Fig. 1.

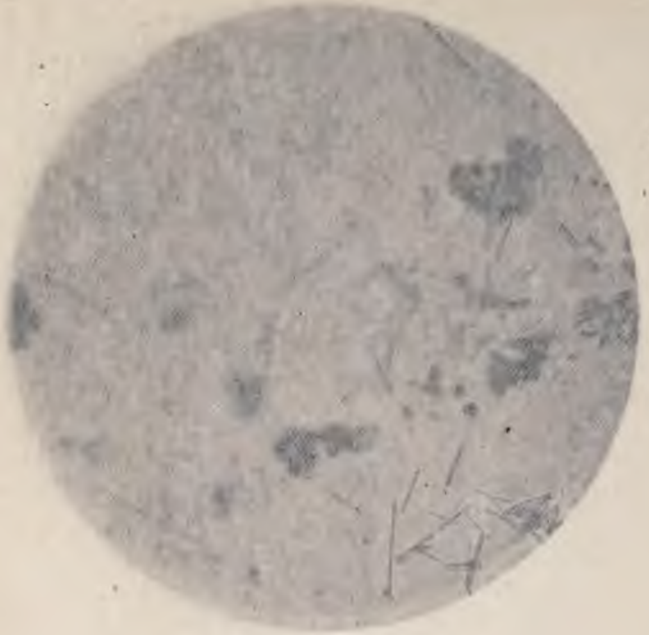
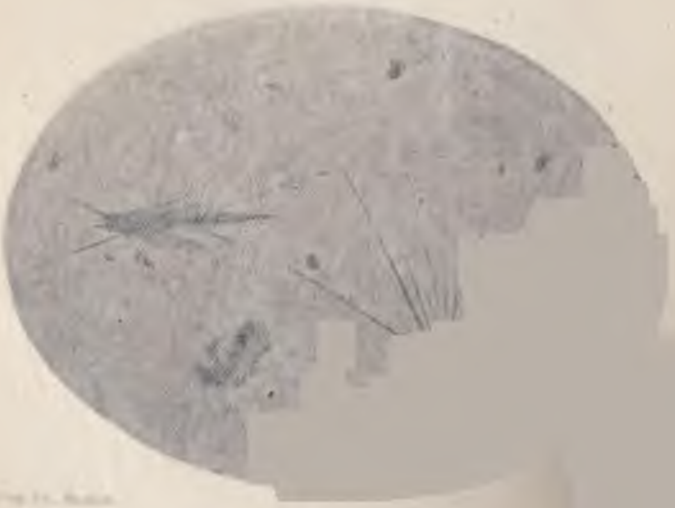


Fig. 2.



Heliotype Printing Co., Boston.

FIG. 3.

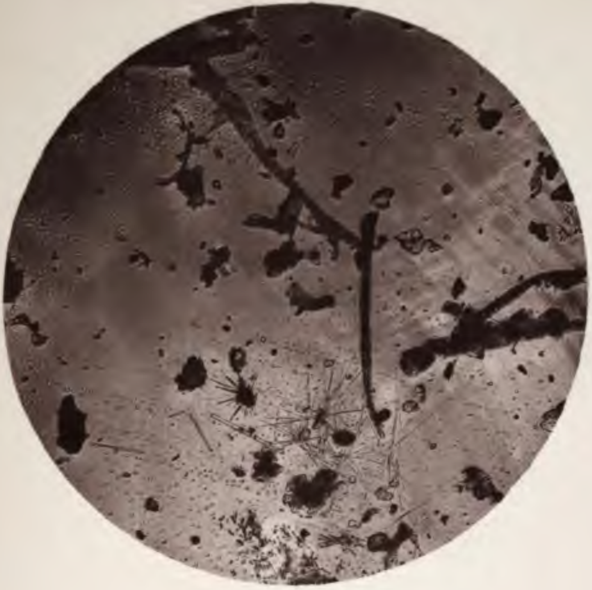
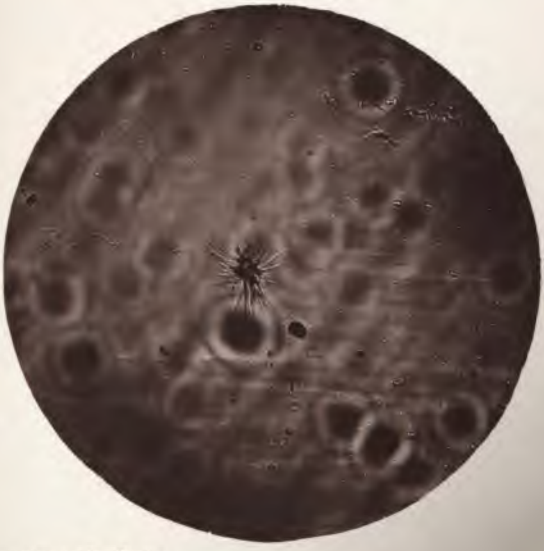


FIG. 4.



Heliotype Printing Co., Boston.

FIG. 5.

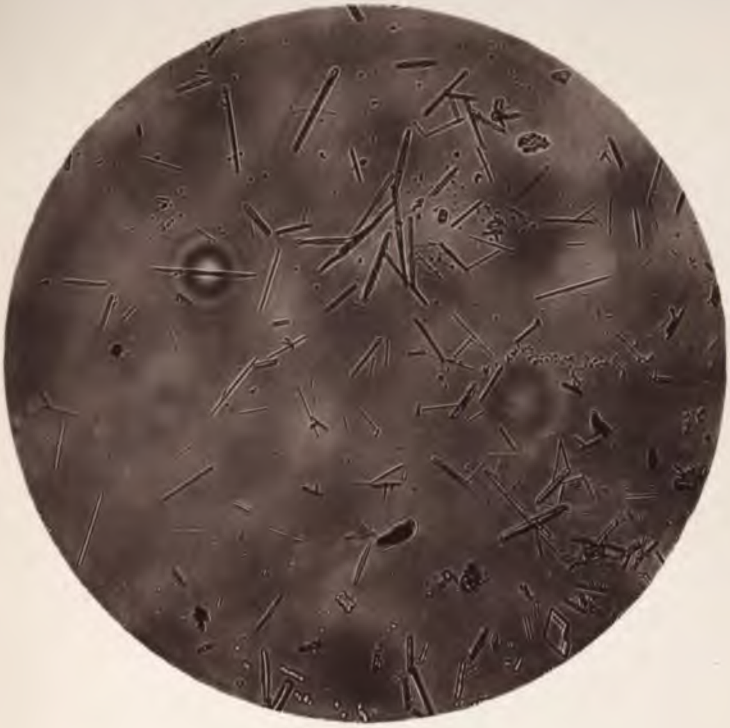


FIG. 6.

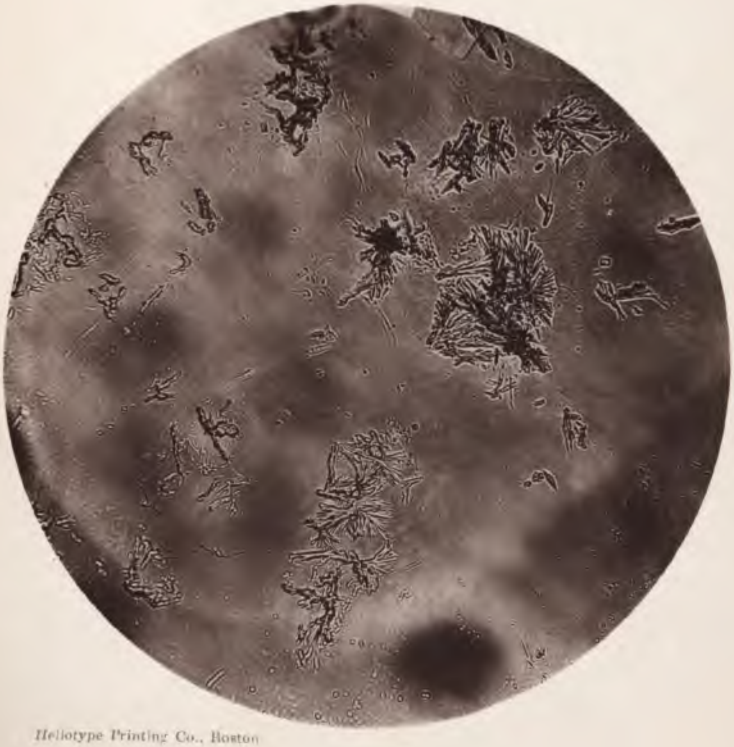


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FIG. 7.

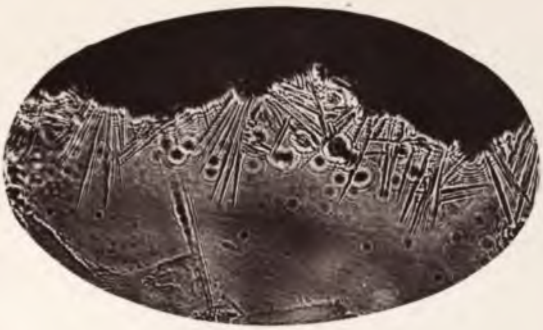
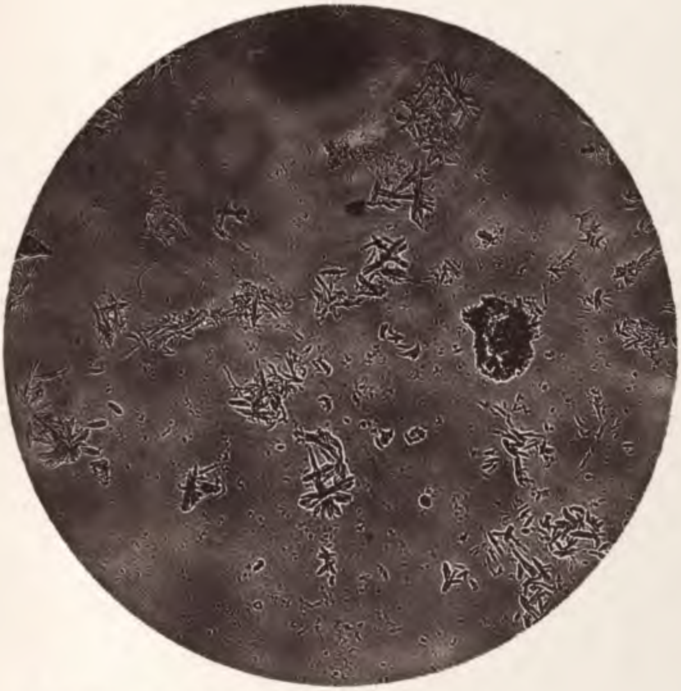


FIG. 8.



Heliotype Printing Co., Boston.

characterized by the presence of the germ itself in the blood, are, from that very fact, strictly *contagious* as well as *infectious*, so would a disease resulting from a secondary toxic agent be necessarily not contagious, as not reproducing the primary exciting cause by the processes of its own clinical history.

Third. A conspicuous characteristic of low vegetable organisms is a certain protective polymorphism, whereby they produce, besides their proper spores, one or more sporelike forms (*conidia*, *sclerotia*, *microzymes*), which remain passive so long as the surrounding conditions are unfavorable to their further development, and are endowed with a remarkable power for resisting extremes of heat and cold. The *sclerotia* of many hyphomycetous fungi are inclosed in a hard coriaceous integument, which effectually protects them against the winter's cold, and within which they retain their potential vitality until the warmth and moisture of the ensuing spring awaken it. Then, after a period of growth, variable according to the species, during

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of experiments undertaken for the purpose of discovering the nature of these appearances, it was found that some forms are closely simulated by the slow crystallization of dilute solutions of *sodium carbonate* and *sodium butyrate* upon glass slides. The needles radiate from an opaque central spot of irregular outline, which appears to be sometimes an unrecognizable particle of dust, sometimes a portion of the salt in a state of partial deliquescence. When the relative humidity of the air rises above the proportion of 75 parts in 100 the crystals are apt to disappear, through deliquescence, leaving minute globules of liquid so disposed as to faintly indicate their outline. Other photo-micrographs taken by the Havana Commission represent microscopic crystals in the form of rods, which are closely simulated by *potassium sulphate* and *ammonium sulphate* when crystallized from dilute solutions upon glass slips. Photo-micrographs of these crystals, of both spontaneous and artificial production, are presented herewith. The moisture condensed from the air upon clean glass vessels containing ice, at various times, has been found to contain *ammonia*, *chlorine*, *sulphuric acid*, *carbon dioxide*, *calcium*, *potassium*, *and sodium*, together with epithelial scales and various solid bodies. The evaporated and incinerated residue effervesces faintly upon the addition of a strong acid, from which we were led to suspect the presence of an organic acid. The condensed moisture was in all cases neutral to test paper. Fox (Water, Air, and Food, Philada., Lindsay & Blakiston, 1878) figures crystals bearing some resemblance to those in question, as deposited from the air, which he conjectures to be *ammonium chloride* (acicular crystals), and *sodium sulphate* (rods). We have not succeeded, however, in producing the forms figured by him from these salts.

which mycelium only is produced, true spores are developed, and the plant may be said to have reached maturity again and to be capable of giving rise to new individuals.[*] Asexual spores (*conidia*) are found in some members of most families of fungi, and the bacterial forms (*Schizomycetes*) after multiplying by fission until the supply of appropriate pabulum in the liquid they inhabit has been exhausted, pass into what has been called the "granular stage,"[†] the *microzymes* of Béchamp.[‡] Whether these are the true spores of bacteria or not must be considered as still uncertain, since Dr. Burden-Sanderson[§] found that the adult form could be produced by germs so minute as "not to be distinguishable under the highest powers of the microscope," while their actual presence was proved by the fact that the liquid containing them lost its fertility after being boiled.

Fourth. The bodies of those who have died of yellow fever are decomposed with unusual rapidity, as though the processes of putrefaction were already somewhat advanced before death had actually occurred. The fluidity of the blood, frequent absence of *rigor mortis*, and peculiar strong odor, also suggest the same idea. Decomposition of organized bodies is so dependent upon the life of lower organisms, that Pasteur has expressed his belief that without their intervention (mucedines, molds, bacteria, etc.) "dead organized matter would be almost indestructible."[||]

It is difficult to account for the remarkable rise of temperature after death, unless it be supposed that unusually rapid chemical changes are going on. Thus Dr. Marvin, house physician to the yellow-fever hospital at Louisville, Ky., records, in an analysis of 70 cases there treated, that "just before death the temperature generally fell to 97°. After death it gradually rose, sometimes to 106¼° in the axilla, the body remaining warm for twelve hours."[¶]

Dr. C. S. Mercier reports[**] the case of a German woman who died at the Charity Hospital. at New Orleans. of yellow fever, with a temperature of 111° 101°? in the axilla two hours before death, of 105.5° in the axilla. and 109° in an incision made through the abdominal walls five hours after death.

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[*] Fungi, N. Y. International Scientific Series, 1875, p. 47.

[†] Magnin, *op. cit.*

[‡] Comptes rendus, lxviii, 877.

[§] Rep. of Med. Officer of the Privy Council, 1870, p. 49.

[||] Watt's Dict'y. Chem., 1879, vol. vi, p. 613.

[¶] Med. Record, December 21, 1878.

[**] N. O. Med. and Surg. Journal, Sept., 1878.

The parallelism between these traits in the behavior of the microscopic organisms referred to. and of the yellow-fever poison, seems to be sufficiently obvious to establish a strong probability of relationship. Suppose the poison to be, for example, a fungus, capable of development outside of the human body, that, under favorable conditions. it is rapidly propagating itself on shore, and that a person receives its active spores upon his clothing, and its infective products (whether primary or secondary) into his system. carrying them to a ship with him. If the conditions in the ship are not those favorable to the continued increase of the organism and to the development of its toxic products, there will be no further extension of the disease than to those persons exposed to the quantity of poison imported. If the conditions are favorable the disease will become almost immediately epidemic. If favorable conditions are not present on shore, but are in the ship, the germ may be brought off in its passive state and spring into activity on board, in which case a considerable interval will elapse before the poison reaches maturity, and the epidemic will appear to have arisen spontaneously within the ship. If the conditions are not favorable either on shore or afloat, the poison, in the form of *conidia*, *sclerotia*, or *microzymes*, may remain passive for an indefinite period, until the proper conditions are presented, as in the rare instances of a first outbreak at sea after a long period spent in a northern port, and with no history of a previous epidemic.* Or, as in the cases of the Plymouth and Susquehanna (see p. 57), the organism may, after reproducing itself for a time, lose its activity, owing to change of climate, to propagate itself anew as soon as it is again placed amid favorable conditions. In short, it is possible to account for all of the apparently inconsistent phenomena of yellow-fever epidemics by referring them to thoroughly well-established facts in the natural history of vegetable organisms whose life history is known. It m even be, considering the probability that a peculiar meteorological condition is necessary to the development of yellow fever as a disease, that the disease and its organic cause are by no means so closely connected as has been supposed, but that the latter may be always present within its geographical habitat, while the former can only be produced when a not always present pabulum has been supplied, from which the toxic agent necessary to the causation of the disease may be elaborated. In a similar way the same vegetable ferments may give rise to different products, according to the conditions under which it is placed. The "mother of vinegar" (*Mycoderma aceti*, Pasteur), for example, when *submerged* in an alcoholic liquid continues to reproduce itself, although its reproduction is no longer attended by the formation of acetic acid, as when the plant had free access to oxygen, but by the production of water and carbonic acid. The same result follows when the organism, remaining on the surface of the liquid, has consumed all the alcohol present.*

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* The General Greene, *e. g.*, La Roche ii, p. 425.

We have thought it proper to recapitulate the arguments which have influenced our conclusions with regard to the cause of yellow fever thus in detail for the reasons that they must necessarily, in the absence of direct evidence, rest upon analogy, and that the practical results to which they lead seem to us to be of sufficient importance to require a full statement of the considerations upon which they are based.

It results from the foregoing discussion that if, as we are inclined to believe, the cause of yellow fever is a product of the development of a microscopic vegetable organism, there is as little hope of success in attempts to keep it out of a ship by any practical measures of quarantine, as the "spontaneous generation" controversy has shown that there is in maintaining the freedom of ordinary water from the presence of organic germs. Coal and provisions are necessaries which cannot be dispensed with even in infected ports, and the former of these has a particularly evil reputation as a carrier of the yellow-fever poison.

Of the five concurrent conditions which appear to be necessary to the production of an epidemic of yellow fever, namely,

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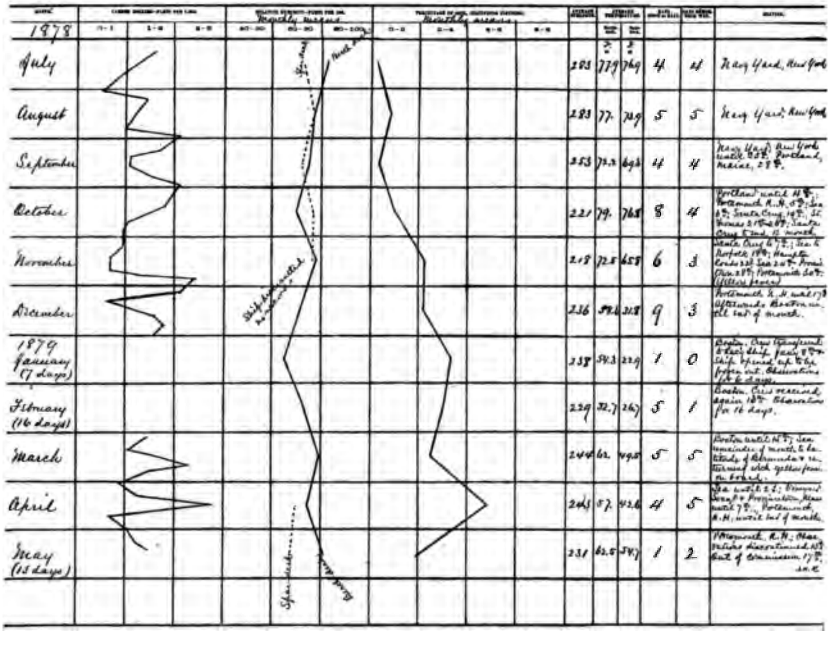
* Duclaux, quoted by Magnin, p. 116.

Diagram compiled from the Meteorological Reports of the
U.S.S. Plymouth. .... Theron Woolverton, Surgeon.



1878						
July	283	77.9	76.9	4	4	Navy Yard, New York
August	283	77.	73.9	5	5	Navy Yard, New York
September	253	72.2	69.2	4	4	Navy Yard, New York until 25th; Portland, Maine, 29th.
October	221	79.	76.8	8	4	Portland until 4th; Portsmouth N.H. 5th; Sea 6th; Santa Cruz 14th; St. Thomas 21st to 28th; Santa Cruz 29th, to end of month.
November	218	72.5	65.8	6	3	Santa Cruz to 7th; Sea to Norfolk 19th; Hampton Roads 22d; Sea 24th; Provincetown 28th; Portsmouth 30th. (Yellow fever)
December	236	38.6	31.8	9	3	Portsmouth N.H. until 17th afterwards Boston until end of month.
1879 January (7 days)	238	34.3	22.9	1	0	Boston. Crew transferred to rec'g ship Jan'y 8th. Ship opened up to be frozen out. Observations for 6 days.
February (16 days)	229	32.7	26.7	5	1	Boston. Crew received again 13th. Observations for 16 days.
March	244	62.	49.5	5	5	Boston until 14th; Sea remainder of month to latitude of Bermuda & returned with yellow fever on board.
April	245	57.	42.6	4	5	Sea until 2d; Vineyard Sound & Provincetown, Mass. until 7th; Portsmouth, N.H., until end of month.
May (15 days)	231	62.5	54.7	1	2	Portsmouth, N.H.; Observations discontinued 15th. Out of commission 17th. S.W.

Average air-space per man on berth-deck was 187.3 feet.
Sick-list gradually increases from July until April.
Berth-deck air usually more humid than that of spar-deck.

high temperature, humidity, a suitable nidus, a peculiar meteorological state, and the presence of the germ, only two are such as can reasonably be expected to be preventable, and these two are humidity and a suitable nidus. Experience has shown that something can be done in the way of preventing invasion of the poison by way of the atmosphere, by anchoring at a distance from the shore* and by restricting intercourse with the shore in infected ports to as few persons as possible and to those parts of the day when the air is at its driest. Such precautions as have been found useful in this regard will be set forth in another place under the head of sanitary regulations.

The series of graphic representations (similar to that of the Plymouth, hereto appended) now in course of preparation from the records of meteorological observations at the Bureau of Medicine and Surgery show that the saturation of the berth-deck air is often greater than that of the external air, and that there is a remarkably close correspondence between the degree of humidity of the air and the daily average sick-list. It is, so far as we can learn, the unanimous opinion of the medical officers of the Navy that the practice of wetting and holystoning the decks below the water-line is the principal cause of this unwholesome humidity, and that it should be discontinued.† In this opinion several distinguished officers of the line who have tried the experiment of maintaining dry decks heartily concur.‡ Commander Sullivan D. Ames, for example, has informed a member of this board that by the use of a judicious mixture of yellow ochre with shellac he has succeeded in covering the berth-deck of a ship in which he served with a water proof coating of sufficient firmness to be permanent, and which was much more easily kept clean than the bare planks. In the frame spaces and beneath floors in ships when every care has been taken to keep all accessible parts clean and sweet. Between the frame spaces of the Plymouth, for example, which was a well-kept ship, we found large semi-solid masses, which proved to be made up almost entirely of bacterial organisms (*Micrococcus* in the zoöglæa stage and *Microbacteria*), for the production of which we are at a loss to account; whether these deposits had or had not any direct connection with the outbreaks of yellow fever on that ship we have no data for deciding, but they show at least that the conditions in the parts referred to were unusually favorable to the growth of one class of low organisms nearly related to those believed to be productive of zymotic

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* See Dr. Daniel M. Burgess's letter to Havana Commission, Prelim. Rep., p. 12.

† "A ship must be kept dry to be kept healthy." * * * "The evaporation from a wet deck supplies water enough to the atmosphere to raise it to its point of saturation." Med. Insp. A. L. Gihon, Naval Hygiene, Washington, pp. 35 and 38.

‡ In this connection see "Air and moisture on shipboard" by Me [illegible] rector Thos. J. Turner, Hyg. and Med. Reps., 1879, p. 667. Scarce [illegible] cal report is received that does not refer to this evil with greater [illegible] ness.

The aspirating pipe was attached to the center of the case, while an outlet pipe communicated with the circumference. On turning the wheel by a crank air was driven toward the circumference by centrifugal force, and drawn in by the aspirating pipe, which communicated with the apartment to be ventilated. The action was to be reversed by changing the connections. At about this time, and later, there is frequent mention in the Transactions of a ventilator devised by Rev. Stephen Hales, and introduced with remarkably good results into various ships; the "Success" frigate (Trans., xlv, p. 410) and the "Earl of Hallifax" (xlvii, letter from Capt. Henry Ellis), for example. Dr. Hales writes to a friend (Trans., xlv, p. 410) that he had given an account of his invention, which appeared to be a mechanical contrivance, to the General Evening Post in September, 1747, but we have not found any detailed description of the apparatus in the Transactions.

On February 11, 1742, Dr. Richard Mead read to the Royal Society (Trans., xlii, p. 42) "An account of Mr. (Samuel) Sutton's invention and method of changing the air in the hold and other parts of a ship," which appears to be the first instance of aspiration by heat for the purpose of ventilation. Mr. Sutton proposed to close the fireplace and ash-pit of the ship's coppers by tight iron doors, and to lead a copper or leaden pipe of sufficient capacity from the ship's hold, bread-room, etc., into the ash-pit. "And if into this principal pipe so laid into the hold, other pipes are let in, communicating respectively either with the well or lower decks; it must follow that part of the air consumed in feeding the fire must be respectively drawn out of all such places to which the communication shall be so made." From a paper read by Mr William Watson (Trans., xlii, p. 62), it appears that Mr. Sutton's plan was tried on board of the hulk, at Deptford, under Dr. Mead's superintendence, in presence of the Lords of the Admiralty, the Commissioners of the Navy, and the President of the Royal Society, with thorough success, lighted candles being extinguished by the indraught into the tubes. The apparatus of Dr. Desaguliers is almost identical, as figured in the Transactions, with the "magazine ventilators" in common use in our Navy some twenty years ago.

diseases, and may be presumed to have been favorable to the growth of others.

Coal has been often credited with being the fomites by which the disease has been imported and its mortality maintained. The inhabitants of many infected ports, Key West, Rio de Janeiro, and St. Thomas, for instance, maintain (erroneously, as the records show) that the prevalence of yellow fever in those ports began with their use as coal depots. Coal was taken into the Plymouth at St. Thomas shortly before the appearance of the disease. The first case was a man employed about the galley, and the greatest number of cases occurred exactly over the coal-bunkers on the port side of the berth-deck. The Brooklyn (see p. 40) had taken in coal at Rio de Janeiro shortly before yellow fever appeared, and the recent outbreak in the Marion was attributed to coal received at the same port.

While all decomposing organic matter is to be looked upon with suspicion, and it may be that coal is more dangerous in this regard, according to a belief widely prevalent in the Navy, than ordinary filth, there is one substance, unfortunately frequently to be found in our men-of-war, which appears to be particularly closely connected with the production of the disease under consideration. *Rotten wood* has been repeatedly singled out as the essential agent in promoting the development of yellow fever. The condition of the Plymouth in this regard has been already described at length (pp. 20, 21, 22), and Dr. Woolverton declared his own conviction that the infection was "confined to the hull of the ship, and particularly to the rotten wood about the berth-deck. * * * It is conceivable that the *materies morbi*, which we thought had been destroyed by cold, may have been able to exist in a dormant state in the thick porous knees or beams."[*]

The Medical Board which reported upon the epidemic of 1873 at Pensacola[†] describes as "decayed wooden sheds" the hospital buildings and marine barracks, which Dr. Tryon had already reported as infected, and as the localities where the disease first appeared.[‡] Surgeon Sternberg states that "the presence of decaying timbers, such as are found about all frame houses, ships, and wharves, is favorable, in some manner, to the preservation and increase of the disease."[*] Dr. Billings gives the same conclusion as an accepted fact;[†] and Deputy Inspector General Donnet states, more cautiously, that "the outbreaks on board the Cadmus and Nettle have been partly attributed by some to the putrefying process of rotten wood on these ships."[‡] Numerous similar instances are cited by La Roche.[§]

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[*] Hyg. and Med. Reps., 1879, p. 695.

[†] Idem., p. 704.

[‡] *Loc. cit.*, p. 467.

On the other hand there is good evidence to show that when yellow fever has appeared in *sound* and well-kept ships, it has frequently not succeeded in gaining a foothold. In the Monongahela, for example, yellow fever occurred three times during the years 1874–'75, without extending to the ship's company in general.[||] The Monongahela was a new ship, and had been unusually well cared for owing to the discomfort suffered from a foul bilge at starting on her cruise.

The decay so prevalent in the timbers of ships is due to "dry rot," which is the result of the growth of various species of *Polyporus*, a genus of *Hymenomycetous* fungi, the fructification of which occurs within pores on the under side of the *pileus* (fruit-bearing organ). The microscopic white threads (*mycelium*) which constitute the body of the plant, penetrate between the bundles of woody fiber and are nourished at the expense of their constituents. The *Polyporus* flourishes to best advantage in dark, damp, and confined spaces, its growth being checked in the presence of light and freely circulating air. In the Plymouth, for example, the ravages of dry rot were found to be most extensive within frame-spaces, beneath flooring-boards, and in dark corners of the berth-deck, far from the hatches. As a result of its growth, it follows that the affected wood loses its firmness and elasticity, becomes brittle, and finally breaks down into dust, covered on the side next the light and air by a thin shell of sound wood which conceals the ravages

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[*] "Report on yellow fever," quoted by Dr. Tryon, *loc. cit.*, p. 466.

[†] Int. Rev., *loc. cit.*, p. 31.

[‡] Rep., p. 117.

[§] Dasher, Pyramus &c., ii, p. 434, *et seq.*, wherein immense accumulations of decaying shavings were found on cleaning the ships.

[||] Dr. Hoehling, San. and Med. Reps., 1875, pp. 479–483.

EXPLANATION OF PLATES.

FIG. 1.—*Helminthosporium*, sp. From U. S. S. Plymouth; mycelium and jointed tænia-like spores, × 140.

FIG. 2.—*Polyporus*, sp. From U. S. S. Plymouth ; mycelium only, × 200.

FIG. 3.—Fragment of white oak affected by dry rot, from the U. S. S. Plymouth ; natural size and appearance.

FIG. 1.

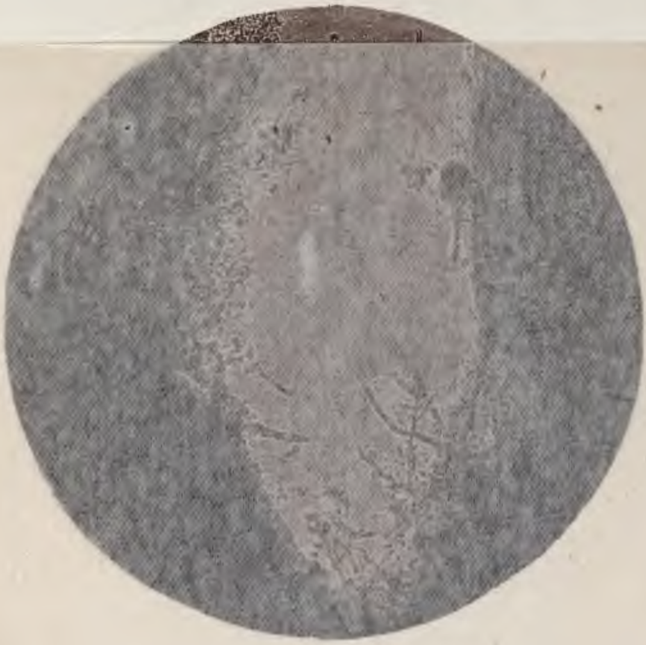
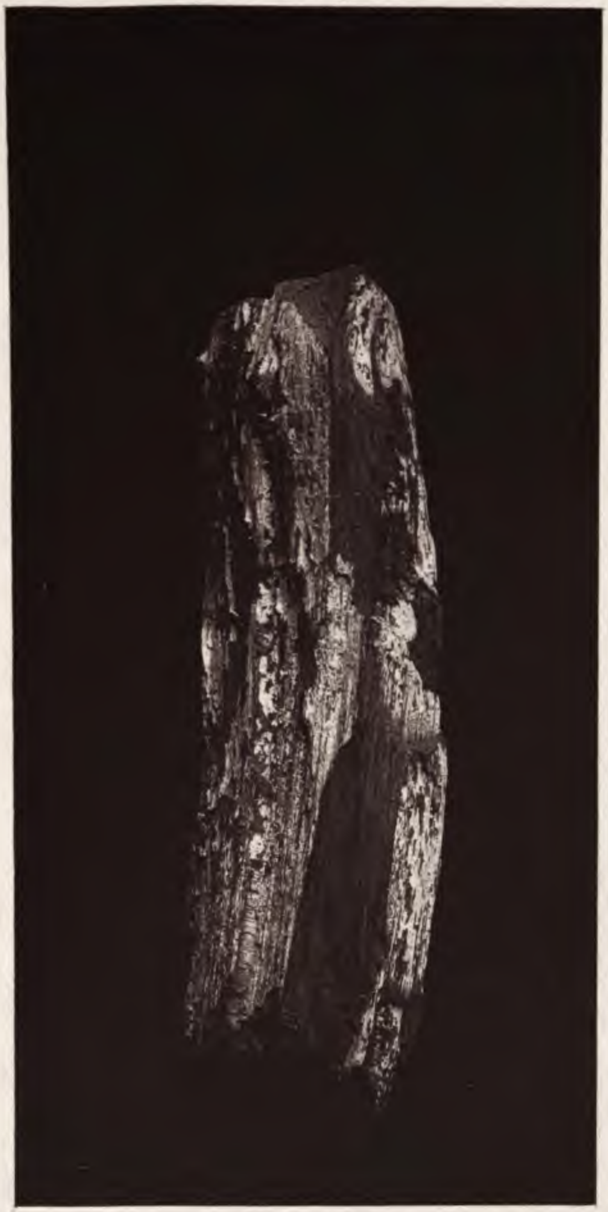


FIG. 2.

Heliotype Printing Co., Boston.

FIG. 3.



Heliotype Printing Co., Boston.

of the parasite until the timber has become so much weakened as to show external signs of giving way.

A peculiarity of the *Polyporus* is its property of growing indefinitely without producing spores whereby its specific nature can be determined. Among the very numerous specimens collected from the Plymouth there were none found that had produced spores. At least two species, characterized by a decided difference in the diameter of their mycelia have, however, been distinguished, and sketches of their microscopic appearance are appended hereto, together with a photograph of a fragment of wood affected by the fungus.

Other fungi, which are not known to promote the decay of wood, were found in the Plymouth bearing spores. One, a species of *Helminthosporium*, found on the under side of a plank which had been used as a keelson cover beneath the floor of the after magazine, presents not only its own proper spores, but numerous *sclerotia*, with minute spore-like bodies which we take to be conidial (or asexual) forms. (See p. 43.)

Measures for *the prevention* of yellow fever in men-of-war should begin with the very construction of the ships, by securing as free access of light and air as is possible to every recess of their hulls. Bearing in mind the fact that the dry-rot fungus flourishes only in dark, damp, and confined spaces, and remembering the heavy annual pecuniary loss resulting from its ravages, measures calculated to interfere with its growth seem to us to need no argument for their adoption.* Such measures are—

1st. Free passage for air through each frame-space, open to the bilge below, and on the spar-deck just below the hammock-rail. Filling-chocks should be scored at the sides, and the fillings around air-ports bored through, the holes to be not less than one and one-half inches in diameter.† In the Alliance a few of the frame-spaces were ventilated by openings on the spar-deck; in the Galena we are informed that most of them are, and in the Lancaster, now under construction at Portsmouth, N. H., this requirement is fully met. Such a construction as has characterized many naval ships (Swatara, Trenton, Monongahela, Tennessee, for example) whereby the frame-spaces were provided with openings only upon the berth-deck, or with no openings at all, is particularly favorable to the production of dry rot, to the destruction of timber, to the injury of health, and to the propagation and preservation of the yellow-fever poison.

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* "How to keep out water and how to get in air are the two great problems of marine sanitary science." A. L. Gihon in Rep. Am. Pub. Health Association. Vol. iii, p. 89.

† See in this connection a valuable paper by Staff-Surgeon John Denis Macdonald, R. N., in Stat. Rep. on Health of the (British) Navy, 1867.

2d. Scuttles or manhole plates in the floors of all store-rooms, shell-rooms, and magazines, so that the skin of the ship, bilges, and bilge-strakes may be made everywhere easily accessible.

3d. The avoidance of all confined-air spaces between bulkheads and the skin of the ship, and behind tin, lead or zinc linings.

4th. The use of as large air-ports as possible, and the admission of as much daylight as possible into the berth-deck space.

5th. The introduction of ventilators, such as those in the Richmond and Lancaster, into all vessels hereafter constructed. This method of ventilation has an especial advantage, beyond the promotion of dryness and constant change in the air below decks, in that its pipes can be utilized for the introduction of disinfecting vapors to all parts of the ship whenever it becomes necessary to use them.

6th. The maintenance of dry decks below the water-line, and of dry bilges, both by the use of subsidiary drying-pumps and by discontinuance of the practice of wetting the gun and berth decks.

As to this last recommendation, we suggest that it would be profitable to institute an investigation as to the most advantageous water-proof coverings for the berth-deck, with a view to discontinuing the practice of holystoning, so far as that deck is concerned, altogether. Should such an inquiry meet with your approval, we suggest that it include also the examination of [illegible] lic coverings, such as copper or lead, for those parts of the [illegible] ath and abaft the engine and fire rooms. Copper is used [illegible] ose in many French men-of-war, but is open to [illegible] ss very accurately fitted to the contour of the [illegible] the occurrence of cracks in the solder by which

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* Bourel-Roncière, *loc. cit.*

its plates are secured to each other. The strong and destructive affinity of fat acids for copper presents also a theoretical objection which it would be well to consider.

Various experiments upon the impregnation of timber with carbolic acid ("Burnettizing") and with barium sulphate (the "Thilmany process") with a view to its preservation, are now being prosecuted in the Navy, concerning which it would be premature to offer an opinion, further than to declare that just so far as they tend to the preservation of the timber from decay they will tend to the prevention of yellow fever and to the improvement of the health of ships' companies. We are informed by Constructor Pook that the Vandalia, which had been "Burnettized," has not suffered from decay in the four years or more that she has been in commission. The recommendations relating to construction, thus far presented, are all being carried out in the Lancaster, now being rebuilt, in a manner that meets with our hearty approval.

Furthermore, we recommend as a measure of prevention that a code of sanitary regulations be drawn up with especial reference to yellow fever, and applying to all vessels cruising within the "yellow-fever zone," in a similar manner to the application of the regulations for vessels cruising on the west coast of Africa. Such regulations should, as we suggest, reasoning from the facts already presented, include the following points, with such others as the experience and wisdom of the officers appointed to prepare them may supply:

a, Restriction of liberty on shore to the hours between sunrise and sunset.

b, Restriction of articles received on board, in ports where yellow fever is epidemic, to provisions only.

c, Careful investigation of the subject of coal supply in ports, usually infected, and of its probable bearing upon the introduction of disease.

d, Authority to commanding officers to leave infected ports, without communication with the department, upon recommendation by the medical officer of the ship.*

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* Such authority has already been granted by the department in particular cases. See order dated December 20, 1875, quoted by Med. Inspector B F. Gibbs, Hyg. and Med. Reps. 1879, p. 244.

e, Anchorage at a distance from shore.*

f, Internal regulations relating to water supply, cleanliness, changes of clothing, discipline, hours of labor, etc.

By the consistent practice of such preventive measures as have been indicated we believe that, while the occurrence of yellow fever on shipboard cannot be altogether prevented, the disease will rarely if ever become epidemic in a sound ship, and that so frightful a loss of life as has characterized the outbreaks in the General Greene (1800), Macedonian (1821), Enterprise (1822), the Hornet (1828), Levant (1842), Éclair (1845–'46), and, more recently, the Susquehanna, Kearsage, and Saratoga can never occur again.†

Too great stress may easily be laid upon cleanliness, to the risk of producing a false sense of security, and of neglecting other preventive measures of equal importance. For, although among the great number of instances detailed by La Roche of the occurrence of epidemic yellow fever on shipboard we have discovered none in which accumulations of filth were not found when the ships came to be broken out, there is no doubt that very dirty ships frequently escape this particular disease when not exposed to its specific cause. The Plymouth's experience is most instructive in this connection, since that vessel was unusually clean and well kept, and but for the immense amount of decayed wood which she contained presented no very obvious explanation of the tenacity with which the disease retained its hold upon her. The Monongahela,‡ on the other hand, being a sound ship, never became *infected*, although invaded three several times. Cleanliness, therefore, while doubtless a preventive measure of vital importance, is to be considered as only one among several to be practiced with equal care and perseverance. A sound, dry, and clean ship, in which the sanitary regulations of which experience has proved the value are carefully observed, will doubtless run far less risk from exposure in ports where yellow fever prevails, than another similarly situated which is rotten, or dirty, or wet below the water-line, or does not observe such precautions, and will escape many times when the latter will suffer severely.

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*See Dr. Pilcher's report; Rep. of Havana Commission; Regulations of French and Spanish navies.

†Dr. Ezra M. Hunt, in a paper presented to the Public Health Assoc., Richmond, November, 1878 (Med. Rec. January 18, 1879), suggests several measures of medical prophylaxis.

‡See p. 51.

When, either because of the neglect of proper precautions or in spite of them, yellow fever has obtained a footing within a naval vessel, it becomes a matter of the utmost importance to know what measures may reasonably be relied upon to check the disease and to prevent its recurrence.

For this purpose we are of the opinion that the use of carbolic acid, chlorine and its compounds, sulphate of iron, nitrate of lead, and chemical disinfectants generally is, however effectual in destroying odors, of very doubtful efficacy in destroying the germs of disease.*

Repeated experiments have shown that these agents even when they suspend the activity of low organic forms fail to destroy them totally; the same bacteria, for example, sometimes resuming their development and active reproduction as soon as they have again been placed in a medium favorable thereto, or as the agent employed has become exhausted by the hydrogen compounds resulting from putrefactive fermentation. An exception to this statement must be made, it appears, in favor of sulphurous-acid gas, which doubtless totally destroys the vitality of vaccine virus,† of the specific poison of cattle plague, and of bacteria, which have been connected with many diseases; even when largely diluted with air.

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* "The weight of testimony is very pronounced against disinfectants." Rep. Yel. Fev. Commission to Am. Pub. Health Ass., session of November, 1878, Med. Record, November 30, 1878.

By a recent report (dated March 26, 1880) to the honorable Secretary of the Navy, it appears that the U. S. S. Marion had been disinfected at Montevideo for sixteen days, an average of fifty pans charged with chlorinated lime and sulphuric acid, and frequently renewed, having been kept below decks, discharging chlorine gas, during that period. Yet when the hold was afterward broken out two of the men so employed were attacked by yellow fever.

† See Surgeon Sternberg's experiments in Bulletin of the National Board of Health, January 17 and March 13, 1880.

A low temperature is doubtless an efficient disinfectant so long as it continues to be present. New cases cease to appear and old cases improve, as a rule, as soon as the temperature of the air falls below 72°. Furthermore, it has happened that ships (the Jamestown, for example*) have become infected, gone to a cold climate, and, having been there broken out, cleaned, and exposed to a freezing temperature for some months, have returned to the yellow-fever zone without suffering from a return of the disease. A bill has lately (1879) received the approval of Congress for the construction, at a cost not to exceed $200,000, of a refrigerating-ship, for the sole purpose of inducing a low temperature in infected vessels.

On the other hand, even prolonged exposure to a temperature below the freezing point has not always secured infected vessels against a return of yellow fever when again subjected to favorable conditions. The experience of the Plymouth is here in point, and that of the Susquehanna is still more apposite. The following published letter from Medical Director R. T. Maccoun† gives a concise statement of the facts:

"A severe epidemic of yellow fever occurred on board the U. S. S. Susquehanna, at Grey Town, Central America, in 1858. The Susquehanna came direct from England and the Mediterranean, a few months before, with a perfectly healthy crew, and yellow fever was unknown at Grey Town. As soon as the fever showed itself the vessel went to sea, bound north, but in the course of a few days so many firemen and coalheavers were prostrated by the disease that she was obliged to touch at Jamaica, *en route*, to procure men to work the ship. By kind permission of the authorities, nearly one hundred cases were landed at the Royal Naval Hospital, Kingston, and the ship proceeded on her way north, the disease still continuing its ravages; and on her arrival at New York, one hundred additional cases were landed at the quarantine hospital.

"Yellow fever had prevailed on board the Susquehanna on a previous cruise; but in the interim she had been exposed he cold climate of the north, and as there was no fever at

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Med. Essays, 1873; Dr. Bloodgood's report, already cited.

Y. Med. Record, October 26, 1878.

Grey Town, and no record that the scourge had ever visited that place, the supposition is that the poison had remained dormant in the hold of the ship, awaiting the proper surroundings of temperature, moisture, etc., to resume its activity. The bilges of the ship were not accessible at their after part, and on tearing up the planking were found very foul; nearly all those who were employed or slept on the lower deck, such as firemen and coalheavers, contracted the fever, while all who were employed or slept on the upper deck escaped, plainly showing the local origin of the disease.

"After the ship had been thoroughly disinfected and fumigated, and had remained exposed to wind and weather for several months, two firemen who were sent on board to examine the condition of the machinery contracted the fever, so enduring was the nature of the poison. After this sad experience, the Susquehanna remained dismantled in the harbor of New York, exposed to the freezing temperature of several winters, and was again put into commission as the flagship of the North Atlantic squadron; but on her return to the tropics the fever reappeared on board of her.

"From the above facts I am led to believe that frost does not kill the yellow-fever germ, but merely renders it torpid until congenial influences and surroundings enable it to resume its activity and reassert its dreadful sway."

While there is some doubt, according to the above interesting letter, as to whether Dr. Maccoun was a believer in importation or spontaneous generation of the yellow-fever poison, there is no doubt of his conviction that the poison was a material entity residing in the ship, nor as to the facts which he recites showing that it retained its potential vitality after the ship had been thoroughly cleaned, fumigated, and disinfected, and after her very prolonged exposure, dismantled, to a low temperature.

Dr. Stillé, in the lecture already cited, speaks as follows of the influence of low temperature:

"But experience has shown that in this way it (the poison) is not always absolutely killed; that its activity may be only suspended, and that when it has prevailed in the autumn it will perhaps prevail in the following year if the weather favor its revival. Again, a transient period of cold weather does not always put an end to an epidemic of yellow fever; if the temperature rises again the disease may break out anew."

It may be, as has been urged respecting the experience of the Plymouth, that there are recesses and protected spaces which are not affected by the low temperature prevailing in the more exposed parts of a ship subjected to the natural freezing process, and that by proper care such recesses could be opened up to the action of a refrigerating-ship. We cannot deny the possibility, so long as the yellow-fever poison remains unidentified, that extreme cold may permanently destroy as well as suspend its vitality.* But, considering the fact that such experiments as have been made with this agent have not always proved successful, and that extremely low temperatures do not permanently destroy the reproductive power of low organisms in general,† we do not recommend that a costly apparatus for testing the value of this mode of disinfection be constructed for use in the Navy until further and positive experiments have demonstrated its efficacy.

Those who advocate this mode of disinfection do so upon the theory that yellow fever is a disease of nautical origin, and that it not only resides within the ship upon which it manifests itself, but is generated spontaneously where it is found. Mr. John Gamgee, who is an able advocate of this mode of disinfection, and who has presented the arguments in its favor at their best in the interesting *brochure* already cited by us, denies that "germs or spores"*, have anything to with this disease, which he considers to be "far more easily, surely, and permanently preventable than typhoid or scarlatina."†

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* The following extract from a letter addressed to Hon. Isham G. Harris March 27, 1879, and signed by Medical Director Thomas J. Turner, U. S. N., Surgeon J. B. Hamilton, United States Revenue Marine Hospital Service, and Surgeon John S. Billings, U. S. A., as to the refrigerating-ship project, is of interest in this connection:

"5th. Whether the production of a temperature even as low as zero, in a ship, for a comparatively short period of time, *id est*, for a few hours, will destroy or render permanently harmless the yellow-fever poison, we do not know, there being now no satisfactory evidence in existence upon this point. But * * * we are of the opinion that the experiment is worth trying."—Gamgee, *op. cit.*, p. 157.

† See Revue Scientifique, Fevriér, 1877, p. 794. "A high temperature kills bacteria, cold benumbs them (*les engourdit*). Their active life is suspended by the cold, as well as their power to produce or to maintain putrefaction." Koch dried infected blood from charbon and kept it more than four years, after which it produced an action as fatal as that of blood freshly drawn from the veins of an animal suffering from charbon. (Translation of a lecture by John Tyndall.)

"Frisch has lowered the temperature of bacteria down to —124.6° Fah., but on warming them again he has developed coccus and further bacteria."—Gamgee, p. 146.

Absolute proof of the theory that the cause of yellow fever is a living organism propagating itself according to the laws which govern other organisms and of definite specific characters, will be almost certainly fatal to the idea of using cold as a disinfecting agent. In the want of absolute proof there is a certain presumption in favor of this theory, the weight of which we have endeavored to set forth in the preceding pages.

Neither, it must be confessed, do we know by actual experiment that a relatively *high* temperature will destroy the germs of yellow fever; nor can we expect to know it until the germs have been isolated and recognized. Reasoning from the natural history of bacteria however, which has been successfully studied with especial reference to the influence of temperature, the use of heat as a septicide affords a better prospect than we find in any other agent.

Pasteur, for example, announced at the session of the Académie des Sciences for January 29, 1877, that exposure of an infected liquid to a temperature of 110° C. (230° Fah.), for ten minutes, or 130° C. (266° Fah.) for five minutes, is enough to insure the death of all germs. Feltz‡ found that one cubic centimeter of putrified blood containing bacteria, mixed with 5 cubic centimeters of water, and injected into the veins of a rabbit killed it in from three to seven days. After heating to 80° C. (176° Fah.) it was still full of bacteria, and fatal in eight days. But exposed to 160° C. (310° Fah.) in a sealed tube for four hours it became innocuous and contained no living organisms. M. Schutzenberger§ states that the fecundity of the spores of all common fungi is destroyed at 130° (266° Fah.).

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*P. 150. †P. 9. ‡Comptes rendus, lxxxiv, p. 353.

§Fermentation, D. Appleton & Co., N. Y., 1876.

Dr. Burdon-Sanderson says: "In the further progress of the inquiry it was found entirely unnecessary to employ so high a temperature as 170° to 200° C. (338°–392° Fah.) in order to prevent the evolution of organic forms, provided that the liquids are protected from contamination by external means."[*] By a series of experiments recently prosecuted by Dr. Wernich, upon the comparative disinfecting powers of sulphurous-acid gas and hot air[†] it appears that exposure for five minutes to a temperature ranging from 257°–302° Fah., is equivalent to exposure for six hours to an atmosphere containing from 6 to 7 per cent. (by volume) of sulphurous-acid gas. In both cases the organisms experimented upon were rendered incapable of reviving. The use of a less proportion of sulphurous acid, a shorter time of exposure, or the application of a lower temperature was followed in some cases by a resumption of activity on the part of the bacteria.[‡]

These citations (and it would be easy to adduce a much greater number) leave no room for doubt that heat approaching 300° Fah., is fatal to the most refractory organisms that have been examined. The mass of evidence is in favor of its efficacy even when applied for but a short time.[§]

Practical experiments upon the influence of a high temperature upon the vitality of the yellow-fever poison have been neither numerous nor definite, yet so far as they go they are uniformly favorable. The common practice of burning infected clothing and buildings shows that there is a popular faith in the efficacy of heat to prevent the reappearance of the disease upon a locality once burned over.[‖]

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[*] Studies of Contagion, Rep. Med. Off. to Privy Council, 1870, p. 55.

[†] Centralblatt für die Medicinische Wissenschaften, vol. xvii, p. 227.

[‡] Dr. Wernich also observed that different fabrics gave up their infections with different degrees of quickness—woolen most readily, linen less easily, and cotton wadding with most difficulty of all.

[§] See Appendix B, Report of Medical Board to examine the U. S. S. Plymouth, dated April 17, 1879: "We believe it is an admitted fact that heat at or above the boiling point of water is more effective in destroying the germ of yellow fever than even cold, and is particularly applicable to ships as being both cheap and effective."

[‖] "The fire of London, it has been observed, was a blessing. It burned down the city; but it burned out the plague." Macaulay's Essay on History, Edinb. Rev., May, 1828.

Live steam has been admitted to the interior of ships of war as a disinfectant against yellow fever, and with success.*

Disinfection by baking has been recommended again and again for quarantine stations, and is not used extensively at this time, not because of any want of faith in its efficacy, but because of the injury that would result to the cargoes of the ships. As already set forth, the navigation and some other stores of the Plymouth were baked at Portsmouth, in the oven used for baking cores, with a view to their disinfection. The temperature was raised to about 260° Fah.

Subsequent reflection and investigation have confirmed us in the opinion expressed in our preliminary report, dated March 10, 1880,† that the best prospect of success in attempts to destroy the poison of yellow fever, when once it has become epidemic in the Navy, is afforded by the use of a gas or vapor at a high temperature. In the hope that it would be possible to combine the advantages of a chemical septicide of known power with those of a high temperature, we then recommended that experiments be instituted upon sulphurous anhydride (sulphurous-acid gas) as to the practicability of introducing it into every part of a vessel, and of maintaining it at a temperature approaching 300° Fah., which we believe to be sufficient to destroy every living thing that it reaches.

Experiments have accordingly been begun and are still in progress, directed to the settlement of the following questions:

1. Can sulphurous anhydride be employed at a high temperature in the interior of a ship without serious injury to the apparatus employed or to the metallic surfaces exposed to its action?

2. Can it be introduced in sufficient quantities to reach every

---

* Yellow fever appeared in the U. S. S. Don, at Sta. Cruz, in November, 1867, having been contracted at St. Thomas. About 15 per cent. of her crew were attacked. The ship was emptied, hatches and ports closed, "and a heavy pressure of steam from the ship's boilers turned in" to the hold, everything remaining closed for twenty-four hours. She finished her cruise in the West Indies without any further outbreak of yellow fever. A very similar history is related of the Mahaska, at New Orleans, also in 1867, followed by a like favorable result. Rep. Med. Board on Plymouth, April 17, 1879.

† See Appendix C.

part of the ship, and maintained at a temperature approaching 300° Fah.?*

1st. Sulphurous anhydride was generated by the action of sulphuric acid upon copper in a glass retort, washed in a Wolff's bottle, dried by passing it through calcium chloride, and heated as it passed through a glass tube coiled upon itself in a spiral of four turns; thence it passed into a flask containing strips of copper and bits of iron wire, and provided with a thermometer. In the first experiment the glass coil was heated by immersion in olive oil raised to 180° C. (356° Fah). No effect upon the copper or iron followed. In following experiments the glass coil was heated directly by a Bunsen's burner, and maintained at a red heat for one hour and twenty minutes, until, indeed, the glass coil was melted so as to lose its form. The thermometer in the flask showed an increase of only 12° C. (31.6° Fah). After boiling the copper and iron wire thus exposed in distilled water, the filtered liquid gave a very faint reaction with baric chloride, showing that sulphuric acid had indeed been formed, but in so small quantity as to be probably harmless to the engine of the ship or to the metal of the superheater.

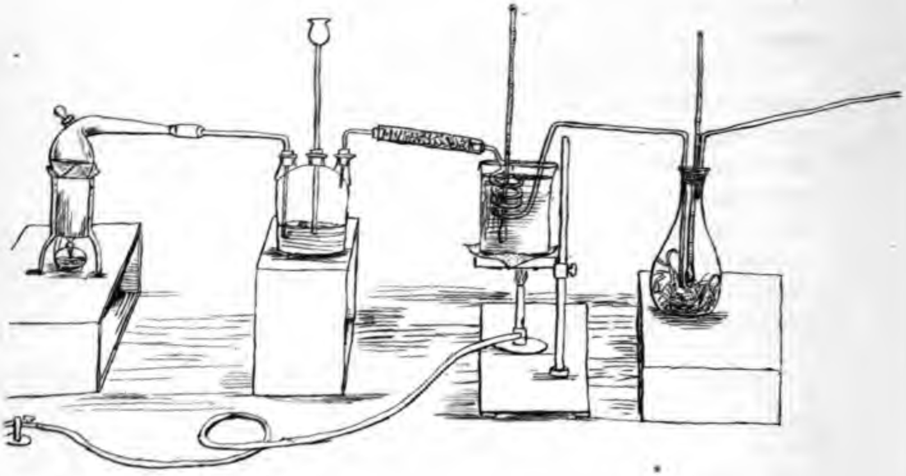
---

* The properties of sulpurous anhydride are as follows:

A colorless pungent gas, resulting from the burning of sulphur with free access of oxygen, and by other methods. One equivalent of sulphur combines with two equivalents of oxygen (SO_2). The gas is liquefied by a freezing mixture of ice and salt, or by a pressure equivalent to three atmospheres, the liquid becoming solid at — 79° C. (— 110° Fah). The observed specific gravity of the gas is 2.247; its specific heat, 0.1544, as compared with an equal weight of water, or 1.62 as compared with an equal volume of air, as shown by the following table of specific heats:

	Equal weights.	Equal volumes.
Water	1.	
Air	0.2374	1.
Steam	0.4805	1.36
Sulphurous anhydride	0.1544	1.62

The gas is decomposed at the temperature of 1200° C. (2192° Fah.), or by a powerful induction spark, into sulphur and oxygen, a part becoming sulphuric anhydride (SO_3) by the combination of oxygen with another portion of sulphurous anhydride. It extinguishes the flames of burning bodies, but metallic potassium and finely-divided tin will burn in it. In presence of steam sulphuric acid is formed and the same result follows more slowly when sulphurous anhydride is mixed with water and exposed to light and air. Several of the metallic oxides will part with their oxygen at a high temperature to form sulphuric anhydride.



2d. The same experiment was repeated with the omission of the calcium chloride. A superheater, made of brass tubing, turned into a close double coil, and exposing ten feet of tubing to the heat of the lamp, was substituted for the glass coil. The pressure of the gas generated in the retort being insufficient to send it through the entire apparatus, an aspirator was attached to its outlet tube. Gas was passed through for two hours and ten minutes, but notwithstanding the increased surface of the metallic superheater, the thermometer in the reception flask (which represents the hold of the ship) showed a rise of only 68° F., a less heat than that which it was desired to produce. No immediate effect upon the copper strips and iron wire in the flask followed, but after forty-eight hours both were found to be corroded and coated superficially with sulphates.

At the temperature obtained therefore (about 130° F.), dry sulphurous anhydride appears not to injure metallic substances with which it may come into contact.* If the gas be moist, however, corrosion will follow in time from the slow conversion of sulphurous anhydride into sulphuric acid (see note, p. 64), in the presence of the vapor of water. There is no theoretical reason for supposing that this conversion will occur more rapidly at the higher temperature of 250° to 300° F., which it is desired to reach, than at 130° F., but an important practical inference from these experiments is the fact that there will probably be some difficulty in reaching the high temperature desired with a gas of so high specific heat as sulphurous anhydride. If the gas can be delivered at the required temperature, however, its high specific heat will render it much less difficult to maintain the temperature in all parts of the ship than would be the case if another gas of lower specific heat should be made use of.

To test the practicability of this part of our recommendation, we proposed to repeat the experiment upon a larger scale, using liquefied sulphurous anhydride in tanks, and so avoiding the necessity for the furnace and blower suggested in our preliminary report. To this end we have arranged with a New York firm for the necessary supply of the liquefied gas, and have procured self-registering thermometers of high range to be placed in the different parts of the ship or apartment to be experimented upon. Unexpected and vexatious delays, arising from a breakdown in the condensing apparatus, have up to this time prevented the firm with which we have contracted from furnishing the liquefied gas, and this final experiment, which we regard as a necessary preliminary to action upon our recommendation, remains yet to be tried.

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* Sulphurous anhydride is used for the production of ice in the apparatus of the Pictet Artificial Ice Co., and is found to possess the "important property of not corroding the metals brought in contact with it, and of lubricating them even in such a way as to avoid the usual operation of oiling." Company's circular.

Should it be found to be practicable to introduce sulphurous anhydride into every part of a ship, and to maintain it within her hold at a temperature of, or exceeding, 250° F., its use on ship-board will present no very serious practical difficulties. Since the gas is condensed under a pressure not exceeding three atmospheres, it can be safely stored and shipped in soda-water tanks, and will afford the necessary pressure by its own vaporization. Proper superheaters, consisting of a double coil of metallic tubing, somewhat similar to the Herreshoff boiler, may be kept on hand at suitable points, or shipped when required. No other apparatus besides a supply of jointed pipe for the conduction of the heated gas to different parts of the ship, and of self-registering thermometers, will be required. The crew and stores of a ship infected with yellow fever having been landed, and every part made as accessible as possible, the conducting tubes should be led fore and aft, as recommended in our preliminary report, the hatches closed, and the hot gas delivered from the spar-deck for such a length of time as experiment shall show to be necessary to the maintenance of a temperature of 250° F. throughout. Should it not be considered advisable to establish a well-appointed disinfecting station, which would doubtless be the best plan to adopt, we conceive that disinfection might thus be effected in ships while still on their stations.

The conclusions to be drawn from the statements of this report are sufficiently obvious, and may be summed up in a few words.

In the first place, we find lying at the very root of the evil described the faulty construction, in a sanitary sense, of the ship herself. Built of materials not protected against the causes of dry rot, and containing many places impossible to be exposed to the benign influences of air and light, she seems to have rapidly degenerated almost from the day of her launching into premature decay. In such a ship the sound condition of the vessel and of the crew she carries are alike imperilled. In her inaccessible recesses masses of organic matter unavoidably accumulate and remain putrescent, unseen, unsuspected, but constantly poisoning the air and inviting disease.

The second consideration which presents itself is that she was provided with stores brought from a place long known to be dangerously infected with the poison of yellow fever. Many of the packages examined by the board bore the mark of the naval store house on the isle of Enchados in the harbor of Rio de Janeiro, where many fatal cases of yellow fever have been engendered. Some of these packages were of a nature well calculated to hold and carry the germs of the disease even through a cold climate.

The third point to be noted is that just before the appearance of the fever on board the Plymouth had taken a great quantity of coal from St. Thomas, a dreaded source of yellow fever, and where the disease was prevailing at the time.

From one or both of these causes of infection came the germ or seed which found a most congenial soil for its fructification in the decayed ship, which had been cruising for years in the yellow fever zone, and which contained beneath the flooring of her holds and store-rooms the putrefying materials which are almost invariably found associated with outbreaks of this disease.

Under these highly favorable conditions the fever naturally became epidemic, as the flame follows the spark falling among inflammable materials.

Once lodged in such a nidus it is easy to understand how difficult it would be to destroy these germs by methods of disinfection ordinarily efficient.

Finally, at the risk of prolixity and tiresome repetition, the board would earnestly call attention to the important lesson to be learned from the experience with the Plymouth.

The ships of the Navy, to be safe from epidemic disease, must be built of timber completely seasoned and prepared, by some state that we decide them to be sporadic instances of yellow fever, supervening upon exposure at night and want of due sanitary precaution.

We, however, deem it prudent to recommend that, for some weeks to come, there be no liberty granted the crews of the vessels now lying here, and that the officers be required to return on board by 10 p. m., save by especial permission of senior officer for longer absence.

Very respectfully, &c.,

SOMERSET ROBINSON, *Surgeon,*
A. S. OBERLY, *Surgeon.*
R. J. PERRY, *Acting Assistant Surgeon, U. S. N.*

To Capt. JOHN H. RUSSELL, U. S. N.,
Commanding U. S. S. Plymouth and S. O. P.

[Telegram.]

KEY WEST, FLA., *March* 29, 1875.

Hon. GEO. M. ROBESON,
Secretary of the Navy, Washington:

Surgeons report yellow fever epidemic in Key West. Have moved squadron except Pawnee. Dictator outside. No cases on board. Await orders.

Captain RUSSELL, *S. O. P.*

APPENDIX A.

(Telegram dated Key West, Fla., Plymouth, March 23, 1875.)

To Hon. GEO. M. ROBESON,
Secretary of the Navy:

Two fatal cases of yellow fever in Key West. Have taken precautions. Will send report and telegraph if more.

Captain RUSSELL, S. O. P.

(Letter.)

U. S. S. PLYMOUTH, (3d rate,)
Key West, Fla., March 23, [1875.]

Hon. GEO. M. ROBESON,
Secretary of the Navy:

SIR: Having received information that there were two cases of fever on shore here, the report of Acting Assistant Surgeon Perry, herewith inclosed with that of Lieutenant Winn, led me to believe they were more serious than represented. I immediately ordered a board to investigate and report, which I respectfully inclose. I have carried out their recommendations. One of the parties, who died after five days' illness, was a telegraph operator. The disease has not been brought to the island, but occurred from the climate. * * *

There is little care apparently taken in the sanitary regulations for the health of the island. Schooner loads of fruits and vegetables are brought from Havana, some in a decayed condition, and sold at public auction on the streets. I will do all in my power to prevent the disease from reaching the squadron, and during the absence of the admiral will immediately notify you of any increase by telegram.

Very respectfully, &c.,

JOHN H. RUSSELL,
Captain and S. O. P.

REPORT.

KEY WEST, FLA., *March 22*, 1875.

SIR: In obedience to your order of this day we have made investigation in the two cases of fever referred to in the papers accompanying, and have to to the officers and men sent to the hospital were removed along with them, the clothing of the nurses employed about the sick was destroyed, and the ship was repeatedly fumigated with sulphurous acid.

From Norfolk the Plymouth came to Portsmouth, N. H., where she remained in quarantine seventeen days and then sailed for Boston, arriving there December 17, 1878.

January 8, 1879, the officers and crew left the ship; the men were transferred with their clothes and bedding to the receiving-ship and the marines to the barracks, where they remained for five weeks.

During this period, January 8 to February 12, there were no fires at any time on board the Plymouth, except one in a small stove in the fire-room, at which the workmen warmed their hands; this was lighted for a few days only. The temperature of the air was generally below the freezing point, and ice formed and remained solid in buckets placed in every part of the ship. The water in the tanks was frozen. Hatches and air-ports were left open, and with the exception of the tanks, chains, and a few shot, everything was removed. Fumigations with sulphurous acid were several times employed, disinfectants were applied to the bilges, and lime-wash freely used. The bedding was aired once at least when the temperature was below freezing. In fact, the disinfecting agencies of cold, fresh air, and fumigation were fully applied to the ship.

February 12 the crew returned on board, and March 15 the Plymouth sailed from Boston for a cruise to the Windward Islands. On the night of the 19th March she encountered a violent gale which rendered it necessary to batten down the hatches. This proceeding made the air of the berth-deck very close and warm, the thermometer marking 89°.

On the morning of the 21st Richard Sanders, machinist, who joined the ship in Boston, was attacked with yellow fever, and on the night of the 22d Peter Eagan, boatswain's mate, became affected with the same disease. Eagan, who was old and somewhat infirm, died on the 31st March. Sanders is convalescing.

The Plymouth was headed for the north, and arrived at Portsmouth, N. H., April 7.

CAUSE OF RECURRENCE OF YELLOW FEVER.

After a careful consideration of all the facts, we have arrived at the conclusion that the infecting virus, which gave rise to the last outbreak of fever, must have been preserved in the rotten wood of the berth-deck or in the bedding or clothing of the crew.

PRESENT SANITARY CONDITION AND RECOMMENDATIONS.

In view of the fact that the Plymouth has been continuously in commission for four years and a half, a greater portion of that time in tropical or semi-tropical climates, that she has had two outbreaks of yellow fever within [illegible] nths, we think it injudicious that she should be kept longer in com- [illegible] e would recommend that the woolen clothing and blankets of [illegible] hed in boiling water and then fumigated with sulphurous- [illegible] wing the ship.

If the department think it desirable, all the stores of the Plymouth, except the woolens (viz, clothing, blankets, flags, and screens), could be landed at the navy-yard without danger of spreading disease, having been first subjected to fumigation. To render the woolen stores safe, it would be necessary to subject them to heat at or above the boiling point of water.

SUGGESTIONS.

It may not be inappropriate here to state that there has never been any exhaustive method of disinfecting our men-of-war returning to the United States with the yellow fever on board.

We would respectfully recommend the following method, which we think will *absolutely* destroy all germs of yellow fever in a ship:

First. After everything perishable has been taken to the spar-deck, the hatches should be fastened down, the air-ports closed, and a steam-tug on each side of the infected vessel injecting steam into the ship, at a pressure of from sixty to eighty pounds to the square inch; this to be kept up for twenty-four hours.

We learn from experts that by this means a temperature from 240° to 250° Fah. can be maintained in every part of the ship.

We believe it is an admitted fact that heat at or above the boiling point of water is more effective in destroying the germs of yellow fever than even cold, and is particularly applicable to ships as being both cheap and effective.

Second. The ship then should be entirely broken out, including water-tanks and chain-lockers, the latter being very often a focus for disease from the mud accumulated in pestilential ports; the ship should then be thoroughly cleansed by scraping and washing with *fresh* water and disinfecting fluids.

Third. After this (if in winter) the hatches and ports are to be opened, wind-sails put down, and the ship subjected to cold at the freezing point of water for two or three weeks.

Fourth. The ship should then be fumigated with sulphurous-acid gas, with closed hatches and air-ports.

If all these agencies can be used, there seems no doubt but that every germ of yellow fever may be destroyed.

It was the fortune of the senior member of this board to witness the efficiency of steam alone in putting an abrupt termination to yellow fever on board the United States ship Don, at Santa Cruz, West Indies, in November, 1867. That vessel was affected with a very malignant type of yellow fever contracted at St. Thomas. She had twelve or fifteen cases among a crew of about eighty men. The ship had orders from Admiral Palmer not to go North, but use every possible means at Santa Cruz to eradicate the disease.

The sick were sent on shore, everything perishable was taken to the spar-deck from below, the air-ports and hatches securely fastened, and a heavy pressure of steam from the ship's boilers turned into the vessel, and every-the sources of disease now existing in her structure. An indispensable preliminary to her sanitation would be the cutting away the decayed and spongy wood, and the unwholesome fungi with which it is filled. Unless this be done in advance the subsequent processes could not be expected to succeed. But the removal of all this decayed mass would involve nothing less than a thorough repair of the ship, for the knees, the frames, the inner planking, the flooring and sheathing of her various dimensions, the filling timbers, and even the main keelson, are extensively decomposed.

Should the department, however, desire that an attempt be made to render her less obnoxious to health, the following plan of disinfection is respectfully suggested as the one most likely to diminish the danger of future recurrence of disease:

1st. A furnace of simple construction for the generation of the gas by the combustion of the sulphur, with free access of air.

2d. A pipe of suitable size to convey the gas to a blower, operated by a small engine, by which the necessary velocity is given to it to conduct it through a superheating apparatus, which may be made by coiling the pipe on itself, in a conical form similar to that of the Herreshoff boiler, and applying heat through the center of the cone.

3d. The pipe continues on to the interior of the ship, where it divides into two branches, one going forward, and the other aft, dipping into the bilges, under store-room floors, inside the ceiling, and under the boilers, &c., by means of subdivisions.

A discussion of the comparative values of different disinfectants, and of the considerations which have led the board to the conclusions here stated, will be presented at length in the final report directed by the instructions, to which this is preliminary. Everything which has come to the knowledge of the board in regard to the reception and propagation of the yellow fever on the Plymouth is also reserved, to be more appropriately stated in the same final report, the object of the present one being only to make the bureau acquainted as promptly as possible with the condition of the Plymouth at the present time.

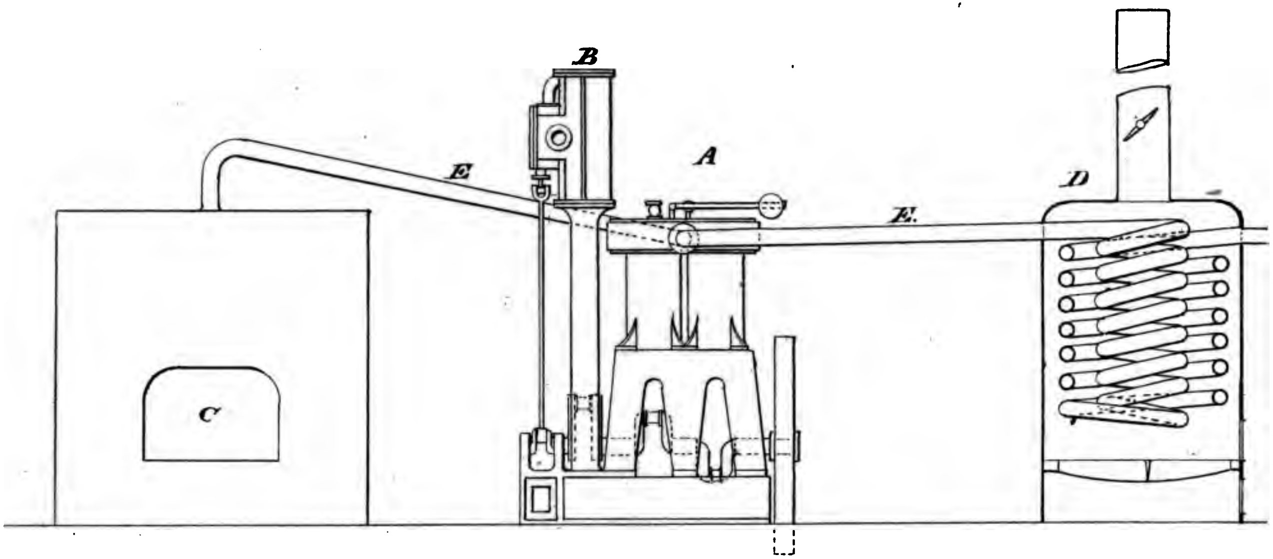
Very respectfully, your obedient servants,

RICHARD C. DEAN,
Medical Inspector, U. S. N., and President of Sanitary Board.
THEODORE D. WILSON,
Naval Constructor, U. S. N., Member of Sanitary Board.
J. H. KIDDER,
Surgeon, U. S. N., Member of Sanitary Board.

COMMANDANT'S, OFFICE,
UNITED STATES NAVY-YARD, PORTSMOUTH, N. H.

Approved *March* 10, 1880.

J. C. BEAUMONT,
Commodore, Commandant.



A	Burleigh's gas compressor.
B	Steam engine.
C	Furnace for generating gas
D	Furnace for expanding and superheating gas.
E	Conducting pipe.

ALPHABETICAL LIST OF AUTHORITIES CITED.

AITKEN'S Practice of Medicine, vol. ii, p. 481.

BATES (Surgeon Newton L.). Hygienic and medical reports, U. S. Navy. Washington, 1879, p. 26.

BEALE (Dr. Lionel S.). Disease germs, their real nature. Philadelphia, 1870.

BEMISS (Dr. Samuel M.). American Journal of the Medical Sciences, April, 1880, p. 450.

BERENGER-FÉRAUD (Dr. L. B.). La fièvre jaune à la Martinique. Paris, 1878.

BILLINGS (Dr. John S.). International Review, January, 1880, p. 30.

BLOODGOOD (Surgeon Delavan). Medical essays, U. S. Navy. Washington, 1873, p. 186.

BOUREL-RONCIÈRE (Dr.). Contributions à l'hygiene des cuirassés. Archives de médécine navale, Mars, 1875, p. 168.

BURBANK (Medical Inspector Charles). Hygienic and medical reports, U. S. Navy. Washington, 1879, p. 707.

BURDON-SANDERSON (Dr. J.). Report of medical officer of privy council. London, 1870, p. 49.

CARTER (Dr. H. Vandyke). On the inoculation of monkeys with spirillar blood. London Lancet, May, 1880, p. 437.

DESAGULIERS (Dr. J. T.). An account of an instrument or machine for changing the air of the room of sick people by either drawing out the foul air or forcing in fresh air, etc. Transactions of the Royal Society, vol. xxxix, p. 41.

ELLIS (Captain Henry). Letter relating to Rev. Dr. Hale's ventilating apparatus. Trans. Royal Society, vol. xlvii.

GAMGEE (John). Yellow fever a nautical disease. New York, 1879.

GIBBS (Medical Inspector B. F.). Hygienic and medical reports. U. S. Navy, 1879, p. 244.

GIHON (Medical Inspector A. L.). Naval Hygiene. Washington, 1875. Report American Public Health Association, vol. iii, p. 89.

GREEN (Acting Passed Assistant Surgeon F. V.). Sanitary and medical reports. U. S. Navy, 1875, p. 753.

GREENFIELD (Dr. W. S.). Pathology of contagious and infectious diseases. London Lancet, May, 1880, p. 397.

HOEHLING (Surgeon A. A.). Sanitary and medical reports, U. S. Navy, 1875 pp. 479–483.

HORD (Medical Inspector W. T.). Hygienic and medical reports, U. S. Navy, 1879, p. 707.

HUNT (Dr. Ezra M.). Paper presented to American Public Health Association, November, 1878. N. Y. Medical Record, January 18, 1879.

JONES (Dr. Joseph). Yellow-fever epidemic of 1878. New Orleans Medical and Surgical Journal, vol. vi, p. 599.

LA ROCHE (Dr. R.). On yellow fever. Philadelphia, 1855, vol. ii, p. 425 *et seq.*

LEACH (Medical Inspector T. W.). Hygienic and medical reports, 1879, p. 709.

MACCOUN (Medical Director R. T., U. S. N.). N. Y. Medical Record, October 26, 1878.

MACDONALD (Staff Surgeon John Denis). On ventilation of ships; Statistical report on the health of the (British) navy, 1867.

MAGNIN (Dr. Ant.). Les Bactéries. Paris, 1878.

MARVIN (Dr.). Records of high temperature after death from yellow fever. N. Y. Medical Record, December 21, 1878.

MEAD (Dr. Richard). Account of Mr. Sutton's invention, etc. Phil. Trans. Royal Society, vol. xlii. p. 42.

MERCIER (Dr. C. S.). New Orleans Medical and Surgical Journal, September, 1878.

PASTEUR (M. L.). Announcement of a microbion as the cause of chicken-cholera. London Lancet, May, 1880, p. 459.

PENROSE (Surgeon Thomas N.). Sanitary and medical reports, 1875, p. 765.

PILCHER (Passed Assistant Surgeon Lewis S.). Naval medical essays, 1873, p. 216.

PROCEEDINGS New York Pathological Society. Medical Record, September 24 and October 22, 1879.

REPORT of Naval Medical Board upon epidemic of yellow fever at Pensacola in 1873. Hygienic and medical reports, 1879, p. 704.

REPORT of obstetrical section N. Y. Academy of Medicine. Medical Record, November 29, 1879.

REPORT of sanitary commission of New Orleans upon yellow-fever epidemic of 1853. New Orleans, 1854.

REPORT of Yellow Fever Commission to American Public Health Association. Medical Record, November 30, 1878.

REVUE Scientifique, Fevrier, 1877, p. 794. Translation of a lecture by John Tyndall.

SCHUTZENBERGER (Dr. A.). Fermentation. Internat. scient. series, New York, 1876.

RNBERG (Surgeon George M., U. S. A.). Preliminary report Havana
w Fever Commission, Washington, November 18, 1879.—Letter pub-
Medical Record, January 11, 1879, p. 46. Experiments on disin-
Nat. Board of Health Bulletin, January 17 and March 13, 1880.

STILLÉ (Dr. Alfred). Lecture on yellow fever. Medical Record, March, 1879, pp. 193 and 217.

TAYLOR (Medical Inspector John Y.). Hygienic and medical reports, 1879, p. 478.

TRYON (Surgeon J. R.). Sanitary and medical reports, 1875, p. 459.

TURNER (Medical Inspector Thomas J.). Hygienic and medical reports, 1879, p. 697.

WATT'S Dictionary of Chemistry. Art. fermentation; also supplement (vol. vi), 1879, p. 613.

WATSON (William). Paper on Mr. Sutton's invention, Trans. Royal Society, vol. xlii, p. 62.

WOODWARD (Surgeon J. J., U. S. A.). Pathological histology of yellow fever, supp. No. 4, Nat. Board of Health Bulletin. April 6, 1880.

WOLVERTON (Surgeon Theoron). Hygienic and medical reports, 1879, p. 659.

INDEX.

Air, crystals deposited from 42
  alkalinity of, connected with yellow fever 39
Alliance, U. S. S., ventilation of 53
Ames, Commander S. D 47
Bacteria, connected with disease 41
  in U. S. S. Plymouth 50
  reproduction of 44
Barton, Dr. E. H 35, 38
Bates, Surgeon N. L 32
Beans, decaying, connected with yellow fever 49
Beaumont, Commodore J. C 76
Bemiss, Dr. S. M 26, 27, 28, 34
Berenger-Féraud, Dr. L. B 28, 29, 31, 36, 38
Billings, Surgeon J. S., U. S. A 52, 60
Bloodgood, Medical Director Delavan 32, 58
Bourel-Roncière, Dr 48, 55
Brooklyn, U. S. S., yellow fever in 32, 40, 51
Burdon-Sanderson, Dr. J 44, 62
Burbank, Medical Inspector C. H 74
Burgess, Dr. Daniel M 47
"Burnettizing," as preservative of timber 55
Byrnes, Assistant Surgeon J. C 10
Carter, Dr. H. Vandyke 41
Coal, connected with yellow fever 51
Coffee, decaying, connected with yellow fever 49
Cold, as a disinfectant 58
Dean, Medical Director R. C 68, 76
Desaguliers, Dr. J. T., ventilating apparatus 49
Disinfection by cold 15, 23, 58
  as practiced in Plymouth 15
  by steam heat 18, 63
  by chlorine 57
Disinfectants ....
Donnet, Deputy Inspector General 26, 28, 30, 3
Don, U. S. S., yellow fever in ....
Dry decks, Commander Ames's method of maintaining ....

Page.

- Dry decks, in French navy 48
- Dry rot 52, 53
  - connected with yellow fever 25, 51
  - in Plymouth 20, 22
- Éclair, steamer, yellow fever in 25, 30, 51
- Enchados, island of, a source of yellow fever 24, 25, 67
- Enterprise, U. S. S., yellow fever in 56
- Famine fever, caused by *spirillum* in blood 41
- Feltz, experiment of 61
- Finlay, Dr. Charles 39
- Frisch, experiment of 60
- Fungi, reproduction of 43
- Galena, U. S. S., ventilation of 54
- Gamgee, John 60, 61
- Ganges, ship, yellow fever in 49
- General Greene, U. S. S., yellow fever in 56
- Germs, minuteness of 42
- Gihon, Medical Director A. L 47, 53
- Gibbs, Medical Inspector B. F 55
- Greene, Acting Passed Assistant Surgeon F. V 32
- Hale's, Rev. Stephen, ventilating apparatus 50
- Hamilton, Surgeon J. B., U. S. R. M 60
- Heat, as a disinfectant 61
  - influence on fermentation 61
- Heffernan, Assistant Surgeon A. C 10
- *Helminthosporium* 53
- Hord, Medical Inspector W. T 74
- Hornet, ship, yellow fever in 56
- Hot air, as a disinfectant 62
- Hunt, Dr. Ezra M., on prevention of yellow fever 56
- Jamestown, U. S. S., yellow fever in 32, 58
- Jones, Dr. Joseph, pathology of yellow fever 26
- Kearsarge, U. S. S., yellow fever in 56
- Kenosha, U. S. S 7
- Key West, yellow fever at 11, 69, 70
- Kidder, Surgeon J. H 68, 76
- Lancaster, U. S. S., ventilation of 54, 55
- Leach, Medical Inspector T. W 74
- Levant, U. S. S., yellow fever in 56
- Lewis, Assistant Surgeon D. O 9, 10
- Macedonian, U. S. S., yellow fever in 56
- Macdonald, Staff Surgeon John Denis 63
- McClurg, Asstant Surgeon W. A 10
- Maccoun, Medical Director R. T 58, 59
- Macomb, Commodore W. H 8
- Magnin, Dr. Antoine 41

Page.
Mahaska, U. S. S., yellow fever in 63
Marion, U. S. S., disinfection of 57
    yellow fever in 51
Mary, sloop, yellow fever in 49
Matthews, Surgeon E. S 10
Mead, Dr. Richard 50
Monongahela, U. S. S., yellow fever in 52, 56
    ventilation of 54
Nott, Dr 33
Oberly, Surgeon A. S 70
Pasteur, M. Louis 41, 61
Pensacola, epidemic at 51
Perry, Acting Assistant Surgeon R. J 70
Pilcher, Passed Assistant Surgeon L. S 29, 30, 56
Plymouth, U. S. S., construction of 7
    examination of 19
    history of 7
Polyporus 52
Pook, Naval Constructor 55
Richmond, U. S. S., ventilation in 48, 54
Rio de Janeiro, a source of yellow fever 24
Robinson, Surgeon Somerset 9, 70
Rotten wood, connected with yellow fever 51
Rush, Dr Benjamin 49
Russell, Capt. J. H 69, 70
Sanitary recommendations 55
Saratoga, U. S. S., yellow fever in 29, 40, 56
St. Thomas, island of, a source of yellow fever 13, 25, 30, 67
Schutzenberger, Dr. P 61
Steam, as a disinfectant 63
Sternberg, Surgeon G. M., U. S. A 26, 31, 42, 51
Stillé, Dr. Alfred 28, 30, 33, 59
Sulphurous acid gas as a disinfectant 15, 57, 62, 66
    experiments on 64, 65
    properties of 64
Susquehanna, U. S. S., yellow fever in 56, 58
Sutton, Mr. Samuel, method of ventilation 50
Swatara, U. S. S., ventilation of 54
Tennessee, U. S. S., ventilation of 54
"Thilmany process" for preserving timber 55
Ticonderoga, U. S. S., yellow fever in 32
Trenton, U. S. S., ventilation of 54
Tryon, Surgeon J. R 32, 5
Turner, Medical Director T. J 47,
Tyndall, Dr. John
Vandalia, U. S. S

Page.

Ventilation, by aspiration, history of 49
Ventilation of frame spaces 53
    of U. S. S. Alliance 53
    in French navy 48
    of U. S. S. Galena 54
    of U. S. S. Lancaster 54, 55
    of U. S. S. Mononhgahela 54
    of U. S. S. Swatara 54
Vermont, U. S. S., yellow fever in 32
Watson, Mr. William, on Sutton's apparatus 50
Wernich, Dr., on disinfectants 62
Wilson, Naval Constructor T. W 68, 76
Woodward, Surgeon J. J., U. S. A 27
Woolverton, Surgeon T 10, 13, 18, 33, 51
Yellow fever, conditions necessary to appearance of 27, 35, 38
    definition and description 26
    disinfection in 57
    fomites of 49
    high temperature after death from 44
    immunity by acclimation 28
        race 29
    in U. S. S. Don 63
        Brooklyn 32, 40
        Enterprise 25, 30, 56
        General Greene 25, 56
      British ship Hibbert 30
        Isis 31
      U. S. S. Jamestown 32, 40, 58
      British ship L'Éclair 25, 30, 51
      U. S. S. Mahaska 63
        Marion 51
      sloop Mary 49
      U. S. S. Monongahela 52, 56
      British ship Nettle 30
      U. S. S. Plymouth, first outbreak 11, 12, 14
          second outbreak 17
          first report on 18, 71
          second report on 19, 75
        Saratoga 29, 40, 56
        Susquehanna 56, 58
        Ticonderoga 32
        Vermont 32
      Brazil 32
    at Island of Enchados 24, 25, 67
      Georgetown, Demreara 31
      Key West 11, 69, 70

Yellow fever at Kingston, Jamaica 30, 39
        Martinique 28, 36
        New Orleans 28
        Panama 32
        Pensacola 32, 33, 40, 51
        Port Royal, Jamaica 30, 39
        Rio de Janeiro 24
        St. Thomas 13, 25, 30, 67
        Sierra Leone 31
    poison, incubation of 40
        nature of 35, 39, 42, 45
    prevention of 47, 53
    probably not contagious 29
    rapid decomposition after death from 44
    zone 6, 27

ERRATA.

Page 33, for Surgeon "T. N. Woolverton" read "T. Woolverton."

Page 37, line 8 from bottom, for "Barlow" read "Barton."

Page 43, line 8 from bottom, insert after "residue" the words "from specimens in which carbon-dioxide had not been detected."

Page 44, line 11 from top, for "Burden-Sanderson" read "Burdon-Sanderson."

Page 46, line 9 from top, for "ferments" read "ferment."

7 PL

OMISSION.

On page 77, next after the title "CARTER, (Dr. H. Vandyke)," insert the following:

CHAILLÉ (Dr. S. E.). Preliminary report of the Havana Yellow Fever Commission of the National Board of Health, Washington, November 18, 1879. (National Board of Health Bulletin, Supplement.)

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